THE PROCEEDINGS

OF THE

UNITED STATES NAVAL INSTITUTE.

Vol. XVI., No. 1. 1890. Whole No. 52.

[COPYRIGHTED.]

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

NAVAL ADMINISTRATION IN ALASKA.

BY COMMANDER HENRY GLASS, U. S. Navy.

In August, 1880, the writer was ordered by the Navy Department to proceed to Sitka, Alaska, and relieve Commander L. A. Beardslee, U. S. Navy, in command of the sloop-of-war Jamestown, then stationed at that place. The Jamestown had been hurriedly fitted out at Mare Island Navy Yard, in the spring of 1879, no steamer being then available for the duty, and sent to Sitka to preserve order among the Indians, and to prevent threatened conflicts between them and the white residents and traders and miners scattered about that portion of the territory.

From the impossibility of the Jamestown's cruising about the tortuous channels and sounds of Southeast Alaska, she remained quietly moored in the inner harbor of Sitka during the entire period of her service on the station, small detachments of officers and men being moved from point to point, as found necessary, by means of the steam launches with which the ship had been supplied when fitted out for that special service.

On reporting for the duty assigned, it was soon found that much more was involved than the simple command of a vessel of war, the

commander of the Jamestown representing in himself the whole machinery of government in the territory, so far at least as affording protection to the lives and property of citizens was concerned—something very foreign to the ordinary routine work of a naval officer in time of peace. The only guides for my action were a copy of the letter of general instructions from the Navy Department to my predecessor, authorizing him to take any steps that he might consider necessary for the preservation of good order in the territory, and his various reports from time to time of his actions, all of which had received the full approval of the Department.

At this time Alaska was absolutely without any form of local government, and was in a condition almost as free from the operation of civil law as the interior of Africa. Our Congress had, since the cession of the territory by the Russian government in 1867, been content with making the whole of Alaska a single district for the collection of duties on imports, with a Collector of Customs at Sitka and deputies at Fort Wrangell and Kadiack Island, extending over the territory certain sections of the Act of 1835, governing intercourse with Indian tribes; these sections, however, related only to the introduction and sale of spirits and breech-loading fire-arms and ammunition, and authorized a contract with the Alaska Commercial Company of San Francisco by which that company was granted for a term of years the exclusive privilege of taking seals on the Prybilof Islands in Behring's Sea. The terms of the treaty of cession guaranteed to Russian subjects, electing to remain in the territory after the change of nationality, all the rights and privileges of American citizens, and the undisturbed possession of their property, but no steps had been taken to secure to them those rights; no courts had been established, nor had any means been provided for the acquisition or transfer of titles to property.

Alaska was for several years after the cession a district of the Military Division of the Pacific, with a portion of a regiment of artillery garrisoning Sitka and one or two other points; but this form of control was abandoned in 1876, and a period of nearly three years elapsed with no exhibition of force, beyond the occasional visit of a revenue cutter, until the administration of affairs was assumed by the Navy Department in 1879.

As illustrating the situation of affairs, the following case may be cited. In the fall of 1879, Commander Beardslee arrested and sent to Portland, Oregon, for trial before the United States District Court

at that place, a miner who had in broad daylight, and in the presence of a dozen witnesses in Sitka, deliberately attempted the murder of a person with whom he had some trifling dispute. The wounded man recovered, and, as actual murder had not been committed, the District Judge directed the discharge of the prisoner. The opinion of the Judge was to the effect that in territory such as Alaska, under the exclusive jurisdiction of the general government, and not organized, only the statutes defining piracy, and such special acts as had been passed by Congress for the government of the territory, were operative, and that, as the offense charged did not come under any of these, the court had no jurisdiction.

The Collector of Customs at Sitka and his deputies were the only civil officers in the territory, and could exercise no authority beyond their routine duties under the Treasury Department. Hence it will be seen that the entire responsibility for the security of life and the preservation of good order in Alaska at that time devolved upon the commanding naval officer. That the difficulties of the situation were not greater must be ascribed to the orderly character of the white population at Sitka and other settlements, and to the generally tractable disposition of the Indians.

Sitka had in 1880 a white population of between two and three hundred, made up of a few Russians who had elected to become citizens of the United States, in accordance with treaty provisions, Russian half-breeds, traders, and a few miners who had been attracted there in the previous year by reported discoveries of rich gold-bearing quartz ledges on Baranof Island near Sitka. The Indian village, or *rancho*, separated in part by a stockade from the white settlement, contained usually in the winter season nearly a thousand persons, living in a straggling row of houses along the beach, a single house often sheltering twenty or thirty men, women, and children. The Indians had a sort of tribal, or rather family, organization; each family, of which there were four at Sitka, having its distinguishing name and crest, or *totem*, such as the Raven, the Wolf, the Bear, and the Whale, and each being under the nominal control of a head man or chief. The powers exercised by these chiefs were very vague, and even the manner of appointment or succession to leadership in the different families did not seem to be regulated by any fixed principle; but generally the office was hereditary in the richest and most powerful families.

Commander Beardslee, whom I relieved, had made while in com-

mand a careful study of the Indian question as it presented itself at Sitka, and displayed great tact and firmness in controlling the Indians and in preserving a good understanding between them and the white settlers. He employed the chiefs as a sort of irregular police force, taking them into the pay of the navy as scouts, thereby greatly increasing their importance and influence among the tribes, the very indefiniteness of their powers assisting him materially. This system, somewhat extended, was continued; the chiefs were put into uniform, assimilated to that of the naval service, their respective districts of the Indian village defined, and they were made, as far as possible, responsible for the condition of affairs in the village and the conduct of the members of their tribes.

It being impracticable to take the Jamestown into the interior channels on which the Indian villages are nearly always located, and the great extent of the territory to the westward making easy and rapid communication impossible, her influence was in a great degree confined to Sitka, and that port became the scene of efforts to improve the condition of the Indians and establish order among them. These efforts were afterwards extended to other points in the territory, and the seat of government was shifted from the quarter-deck of the Jamestown as occasion demanded.

Affairs went on quietly enough for some time after my arrival at Sitka, and my attention was directed chiefly to preparing the ship for the coming winter and to settling occasional disputes on shore that were submitted to me for arbitration. But with the approach of bad weather and the long nights of the dreary winter in that latitude, the Sitka Indians began to return from their summer hunting and fishing camps, and it was soon apparent that some active measures must be taken to suppress the disorder that at times reigned supreme in the village and often turned the night into pandemonium. Fighting was of almost daily occurrence, frequently attended by serious wounds to the parties engaged, and the howls of drunken Indians, rioting and dancing about their camp fires, could be heard on board the ship at almost any hour. To remove, as far as possible, the danger of collisions between the white people and the Indians, the latter were compelled to leave the limits of the white settlement each day at sunset, and no white men were allowed to go into the Indian village at any time except under orders for duty.

Drunkenness was found to be very prevalent, the Indians having been taught by white men to distill a wretched sort of rum, called

Hoo-che-noo, from molasses supplied them for the purpose by the traders. The process was very simple, and required only a crude apparatus that the Indians could readily procure. A mixture of molasses and water, fermented by the use of yeast made from the roots of certain plants, was put into a boiler, usually made from an old coal-oil can, and set over the fire in the middle of the house. The worm was made of a bent tin tube, or in some cases an old gun barrel served this purpose; a stream of water was usually directed on the tube, and a wooden bowl received the spirit as it trickled out. The process could be carried on day and night, and it was subsequently found that in the village of fifty or sixty houses over two hundred of these primitive distilleries were in operation in December, 1880.

This condition of affairs is not so much to be wondered at, taking all the circumstances into consideration. The short winter days of that latitude give the Indians little opportunity for hunting and fishing, and the long nights are without any amusements known to civilization. Ignorant, intensely superstitious, and compelled to endure several months of enforced idleness, with no mental employment, gambling and drunkenness naturally became habits of these Indians, and they eagerly embraced the means of intoxication so readily supplied them.

Becoming convinced that some measures to end the scenes of drunkenness and violence constantly presented in the village were absolutely necessary, it was decided to commence at the bottom and stop the importation and sale of molasses. As no law existed for this, a meeting of all the citizens was called at the Custom House, the situation and its needs fully explained, and all the traders were urged to enter into an agreement not to import molasses into the territory from that time, and not to sell any large quantity of molasses at one time to any Indian. Several of the traders showed a reluctance to sign an agreement that would cut off a considerable portion of their trade, but upon a significant hint from one of the miners present that, if the commander of the Jamestown would send all his officers and men on board ship and promise to know nothing of what was going on ashore for a few hours, it would be put out of the power of any one to sell molasses to Indians in Sitka, all hands came into the agreement, which was thereafter faithfully observed. But as it was known that many of the Indians had bought considerable quantities of molasses and had it stored in their houses, in readiness

for making the usual winter supply of fire-water, this agreement of the traders was only a beginning.

The chiefs were next called together and told that the manufacture of Hoo-che-noo must immediately stop, but all declared their inability to put down what they nevertheless loudly declared to be the ruin of their tribes. One of the chiefs, Ana-hootz, who was looked upon as an authority by the others, suggested making a raid on the village and destroying all the stills and molasses as the only effectual means of dealing with the evil. All agreed that this would be the only means of stopping drunkenness among their people, and they united in a request that it should be adopted. This had been done by Commander Beardslee in the previous year, but on that occasion the houses of the chiefs had not been subjected to search and their stills had not been molested, hence their readiness in advocating the raid.

After waiting for some days for any uneasiness among the Indians to subside, the chiefs were assembled on board the Jamestown and told that the raid had been decided upon as they had requested, and that all preparations had been made to carry it out successfully. Three of the ship's boats, fully manned and armed, were in readiness, under command of the executive officer, for landing, and the entire marine guard of the vessel sent on shore. All being ready, signal was made from the ship, the marines were marched into the village at the double quick and posted in rear of the line of houses to prevent any stills being carried out and secreted, and the boats pulled in for the beach. The blue-jackets were landed in three parties, in the center and at each end of the village, and being provided with axes and hammers, commenced at once their work in aid of the cause of temperance. Every house in the village was carefully searched, no exceptions being made. The Indians looked on in sullen astonishment, but no resistance was attempted by any one, and finally many of those whose stills had been first destroyed joined actively in the work, and were of assistance in hunting out concealed stills and stores of molasses, showing a childish glee at the discomfiture of those who had supposed themselves secure. In all, over two hundred of these stills were found and destroyed, with a great deal of molasses prepared for distillation. In one house five stills were found ready, or in operation, with six barrels of molasses, the owner of the house being a distiller of some prominence in the community, the quality of whose Hoo-che-noo enjoyed a great

reputation. He was allowed to sell the molasses not needed as food for his family.

The night following this raid was the quietest one the village had enjoyed for several months, and from that time no serious affrays ever occurred among the Sitka Indians.

A few of the stills escaped the general destruction, but they were discovered and broken up within a few days, and the manufacture of Hoo-che-noo became a lost art at Sitka.

The principal winter employment and amusement of the Indians having thus been destroyed, it was necessary to give them something else to do and think of, and this was done in establishing a general system of cleaning and draining the village, which was in an indescribably wretched condition.

The village was built on sloping ground in front of some low hills, which, in the almost constant rain of the winter season, sent down small streams of water that in many cases entered the houses in rear, and converted all the spaces between them into mud-holes, while all the filth and refuse from the village were thrown on the beach. The Indians were set to work, under direction of some of the officers and leading men of the ship, digging a deep ditch in rear of the houses, with outlets at intervals running down to the beach; earth was heaped up about the sides and in rear of the houses to prevent the water's running into them, and the beach was cleaned up, smoothed, and neatly gravelled down to low-water mark. The sections into which the village had been divided were in charge of their respective chiefs, and daily inspections were made to ascertain that the orders given were properly carried out.

Of course, there were some cases of holding back, and even of resistance to the new order of things, but a judicious system of confinement in the guard-house for a day or two at a time, with the infliction of small fines of blankets, the usual currency among the Indians, soon convinced the most conservative among them that it was wisest to join in the march of improvement. A very few days sufficed to make a decided change for the better in the appearance of the village; the Indians themselves soon began to appreciate the benefits resulting from their enforced labors, and no trouble was found in continuing the system.

Finding a great deal of sickness existing in the village, a dispensary was established on shore under charge of the senior surgeon of the vessel, who showed great interest in the efforts to improve the

condition of the Indians, and who willingly treated all cases reported to him. This, and the improved cleanliness of the village, resulted in a few months in a perceptible decrease in the mortality, especially among the Indian children.

With the change in the condition of the village there was soon noticed a change in the habits and appearance of the Indians themselves. More and better articles of clothing were bought from the traders; about the village there were seen fewer Indians whose clothing consisted of a single blanket; cooking stoves were in some cases bought and used instead of the open fires with kettles hanging over them; lamps appeared in some of the houses, and, above all, soap, to which the Alaska Indian is usually a total stranger, became an article of steady and increasing consumption.

A number of new and smaller houses were commenced, many of the Indians showing a disposition to abandon the usual communal system of living practiced all over Alaska.

Frequently a family consisting of several generations will be found living in common in a single house. The usual Indian house in Southeast Alaska is a large square structure, built of hewn timbers planted upright in the ground, with no partitions. The sleeping quarters are usually narrow, raised platforms running around three sides of the house. The fire for warming the house, cooking, and giving such light as they need at night, is built on the ground in the middle of the house, the smoke escaping through a hole in the roof left for that purpose.

Under such circumstances any improvement in the moral condition of the people is almost impossible. Those who showed a disposition to abandon this mode of living were usually the younger members of a family, who would leave the older ones in possession of the family house and set up for themselves in a smaller one as near at hand as possible. The separation of families was encouraged as far as practicable, and assistance given to those desiring separate homes: their houses were planned for them, and they were often assisted by some of the men from the Jamestown in putting them up.

At the time spoken of, the Alaska Indians were almost entirely without education of any kind, only a few faint attempts having been made in that direction in the territory. The Russian Government had caused a few Indians to be educated, with the purpose of using them as missionaries of the Greek Church among the different tribes; but no attempt had been made to educate and improve the

Indians as a race. The New York Board of Home Missions had sent out two or three missionaries to Alaska, and a teacher sent out by the same body had attempted to establish a school for Indian children at Sitka in 1879. The first teacher had resigned and been replaced by a young lady specially educated for this work, who was making a brave effort for success, but under the most discouraging circumstances, when the improvements in the Indian village were commenced. A visit to the school, established in an old building originally intended by the Russians for school purposes, afterwards used as a hospital for a time, then abandoned and fast crumbling to decay, showed a picture of earnest, faithful work that could apparently result only in failure unless a change could be brought about. The schoolroom was bleak and desolate, the furniture consisting of a table and a few rough benches, and with no means of instruction save a few elementary books not sufficient in number for the few children present. The number of children attending the school varied so greatly from day to day, and their ages were so dissimilar, that no systematic teaching seemed possible.

Interest was excited in the undertaking—the enthusiasm of the young teacher being contagious; all school books and appliances in the trading stores at Sitka were bought,—a meagre assortment at best,—and orders sent to San Francisco for a larger supply, the fund accumulated from fines imposed on the Indians for petty misdemeanors being used for this purpose. Compulsory education was decided upon and put into operation at once. A census of the village was taken and all children between the ages of five and fifteen years were enrolled and required to attend school, the number reaching nearly two hundred.

To make this system effective several practical difficulties had to be met and overcome. From the number of children living frequently in the same house there was, of course, great difficulty in distinguishing them. Even where they had any names beyond those of the families to which they belonged, the teacher was unable to use them in mustering her scholars, and the Indian heads of families would have paid little attention to an order to send their children to school unless some means had been found to enforce obedience. To meet these difficulties each house in the village was numbered and the number of children of each sex noted. Then one of the men of the ship was directed to make a number of circular tin badges equal to the number of children enrolled for school purposes. On each of

these badges was stamped the number of a house, with the sex and number of each child belonging to it, commencing with the oldest. These badges were worn suspended about the neck by a cord, and became a ready means of identifying the children. A muster was held every morning and all absentees reported, noting carefully the numbers of the houses and the number of children that were absent from each house. These reports were handed to the officer in charge of the guard-house on shore after school hours, and on the following day the oldest man in each house from which absentees were reported, who was presumed to be the owner and head of the family, was arrested and brought before the commander. If no valid excuse was presented for keeping the children away from school, the head of the family was punished for disobedience of orders. The usual punishment was a fine of a blanket or restraint in the guard-house for a day. The sum realized from the sale of blankets collected as fines was applied to making improvements about the school.

Only a short time was needed to convince the Indians of the value of education, or at least of the advisability of having their children attend school regularly, and it became a common thing to see an Indian taking several children up to the school building for delivery to the teacher. In many cases the parents, after taking their children to school, would remain as interested spectators, the total number present on some days reaching nearly three hundred men, women, and children.

The success of this effort to introduce education among the Indians, and the readiness with which some of the children learned, led to the establishment at Sitka of what was intended to become a manual training school for Indian boys, under the general management of the Board of Home Missions, a portion of the same building being used. This undertaking was encouraged and assistance given by the officers and men of the Jamestown in repairing the building, fitting up a dormitory for the boys, and laying out a garden. When the school was fairly established in July, 1881, it had twenty boys, varying in age from eight or ten to twenty years, who had gladly left the Indian village to obtain the instruction given, while living in a greater degree of comfort than was possible in their former homes. The expense of maintaining this school is borne by the Board of Missions; it has since been enlarged and a department for girls added, and the latest reports are encouraging for the future.

While this school is reported to have been attended with some

degree of success, it is to be regretted that the instruction given has not been of a more practical character, as was originally intended. Had it become really a school for teaching useful trades to boys and girls, far more good would have been accomplished in improving the conditions of life among the Indians than by all the teaching of catechisms and church dogmas that could ever be given them. It is to be hoped that the very liberal appropriation made by the last Congress, for the support of education in Alaska, will be utilized in the establishment of training schools for boys and young men where they may learn trades useful to them in the present condition of the territory and in its future development, and that other instruction, except in rare cases, will be confined to the English language alone. Even the ordinary branches of a common school course cannot be advantageously taught, except in very few cases, and an effort to do so will be productive of no lasting good.

Singularly enough, as investigations into the habits and customs of the Alaska Indians were pursued, a well-established system of slavery was found to exist in the territory, although over thirteen years had elapsed since the date of cession to our government. The slaves were held by a title of ownership as absolute as ever existed in any of our Southern States, the owners having even the power of putting slaves to death at their pleasure, and in times quite recent it was not an unusual occurrence for one or more slaves to be sacrificed at the burial, or rather cremation, of the former master, to accompany him in his future life.

This next required attention, and the names and ages of all persons held in slavery, with the names and families of the owners, were ascertained as far as possible. In Sitka alone nearly twenty slaves were found, varying in age from mere children to old men and women. The children were descendants of slaves, as, since the American acquisition of the territory, the Sitkas had been engaged in no active wars in which prisoners had been made, the usual custom having been to kill or make slaves of all captives not ransomed.

After informing the leading men of the village that no form of slavery could exist in any territory of the United States, the entire population of Sitka was assembled on the parade ground, and a formal order read declaring slavery abolished in the territory. It was also declared that any person attempting to exercise any right of ownership over another would be severely punished. Taking advantage of the superstitious reverence in which any written docu-

ment is held by the natives of Alaska, a paper had been prepared for each of the liberated slaves and delivered in presence of the former owners. These papers gave the names and ages of the holders, and recommended them to the protection of all officers of the government. Attached to each paper was the seal of the Jamestown, with the signature of the commanding officer.

Some of the interested parties were inclined to contest this very summary deprivation of their property, but these cases were few and confined to those who had acquired slaves by purchase. A few decided words caused all to submit to the inevitable, and in no cases were any of the new freedmen molested. Many of the latter soon took advantage of their newly acquired freedom, and returned to their native villages, from which they had been taken as mere children. The same order was published among other tribes, and was, it is believed, generally obeyed, and the slaves in that portion of the territory liberated.

The Indians in all parts of Alaska are grossly superstitious, and stand in abject fear of their Shamans or witch-doctors. These Shamans are said to be selected for their peculiar office at their birth, and the cardinal requirements for fitness for it seem to be never to cut or dress the hair or allow any water to touch the person. Before final admission into the ranks of the regular practitioners, the candidate is subjected to various severe ordeals testing his endurance of hunger and exposure. They are supposed not only to have the power of discovering witches and counteracting their spells, but also of calling up their own familiar demons to annoy or punish any who offend them; hence the great terror in which they are held by all Indians. An Alaska Indian would prefer at any time to engage a grizzly bear in single-handed fight rather than to touch one of the charms used by a Shaman in his incantations.

This superstition was discouraged as far as possible, and the witch-doctors were warned that they would be severely punished if found at any time practicing their profession. The usual course of procedure was, when an Indian was ill, to call in one of the Shamans, who, after some incantations and beating on tom-toms, would declare the sick person under the spell of some witch, and exact a fee for discovering the witch and dissolving the spell, the fee being in proportion to the wealth and importance of the patient. The fee being agreed upon, the Shaman usually selected as the witch to be denounced some helpless old crone, or member of the community

without friends, who would be arrested and put in close confinement, beaten and starved until confession was made, the witch died, or the sick person recovered. In some cases the witches were burned alive.

During a short absence from Sitka, in January, 1882, a case of witch-denouncing occurred there, of which I was promptly informed on my return. Fortunately, the accused witch was rescued by some of the miners and others in Sitka, who heard of the case before he was put to death. An investigation left no doubt of the guilt of the leading Shaman of the village, and he was arrested and confined in the guard-house just as he had about completed all his preparations for leaving Sitka in a very hurried manner. All the Indians were assembled in front of the guard-house, the witch-doctor was brought out, and the case and the absurdity of his pretensions explained through an interpreter. It was announced that the Shaman's hair would be cut off close to his head, that he would be scrubbed thoroughly, to deprive him of the supernatural powers he claimed, and then be kept at work for a month, and afterwards banished from the Sitka settlement. He was first invited, however, to test his powers, in presence of the Indians, in bringing any plagues he chose on the commander and his officers and men. The sentence was carried out, to the great delight of all the Indians present, but banishment was not found necessary, as the Shaman was not proof against the ridicule to which he was subjected, and left the village of his own accord at the expiration of his confinement. This case seemed to have a good effect in breaking down the witchcraft superstition, and no more cases occurred for some time; none, at least, that were made public.

A peculiar Indian trait is shown in the patience with which tribal feuds are kept alive for many years, with occasional outbreaks of active hostilities. In one case a sort of intermittent war had lasted for nearly eighty years between the Sitkas and the tribe living at Fort Wrangell. The origin of the war, which had caused the loss of a great many lives on both sides, was unknown to the present generation, but it was a point of honor with both tribes to carry on hostilities as occasion served until an equality of losses had been secured. According to the universal custom among the Alaska Indians, the death of any member of a tribe, if occasioned in any manner, however innocent, by another, demands the death of a member of the offending tribe of equivalent rank, or the payment of a number of blankets equal to the computed value of the man to his tribe.

The balance had, in the war mentioned, apparently inclined to one side or the other from time to time by the murder or capture of single individuals or small hunting and fishing parties, an equality never being secured, until neither tribe dared to approach the territory claimed by the other. As this state of affairs was unfortunate for the Indians, and annoying to the white men coming into the territory as prospectors and to establish fisheries, it was decided to make an effort to put an end to it.

The tribe at Fort Wrangell was directed to send three of their leading chiefs to Sitka for a conference with the Sitka chiefs, a safe-conduct being furnished them for the purpose. On their arrival at Sitka they were called on board the Jamestown, where they were met by the three oldest Sitka chiefs, and peace negotiations opened, presided over by the commanding officer, assisted by an interpreter. After grave deliberations on the part of the chiefs, lasting several days, during which as accurate a computation as possible of the losses on both sides was made, it was decided that the two tribes were as nearly even on the general result as they could hope to be, and a formal treaty of peace was drawn up and presented to the chiefs for signature. All gladly acquiesced in the decision and the terms of the proposed treaty, the chiefs signing it with their totems. Copies of the treaty were exchanged and carefully preserved by each tribe, and the terms faithfully observed. Feasting was indulged in for some days, and the Fort Wrangell Indians returned to their homes, very happy over the result of their mission. Other tribal feuds were ended in the same manner.

In all dealings with these Indians they were found to be proud, sensitive, and generally truthful, with a high sense of justice. They have great respect for white men of character and force, and are easily controlled when convinced that any system established for their government is just and equal for all in its operations. A case in point occurred in the summer of 1881, soon after the military post was established at the mining camp of Juneau City. A chief of one of the tribes living at some distance in the interior made his appearance at the post, accompanied by a number of his warriors, to ask the assistance of the officer in command in the adjustment of a claim made by some members of his tribe against one of the traders. The claim, on investigation, was admitted by the trader to be just, and a satisfactory settlement made promptly by him. The chief was highly delighted with the course taken, and expressed his entire

conversion to the new mode of settling difficulties. He explained that it would have been quite easy for him to have obtained satisfaction in the usual way,—by killing the trader on the first opportunity that occurred,—but that having heard of the newly established system of administering justice, he had decided to give it a fair trial first, reserving to himself, however, the right to fall back upon the old custom, had justice or a hearing been denied him.

The Indians show a great desire for improvement in their surroundings and for acquiring property. Indeed, the possession of property is with them one of the chief claims to consideration. With such characteristics, the race, if properly treated, may become of great use in the future in the development of the fisheries and mines of Southeast Alaska, which are already valuable. But if they should be subjected to the course of treatment usually shown to Indians on government reservations, the result could not fail to be disastrous; it would certainly entail great expense on the government and lead to the extinction, in a short time, of a very interesting people.

Late in the fall of 1880 some discoveries of gold-bearing quartz ledges were made at a point on the mainland, about one hundred and fifty miles from Sitka, but within the territory of the United States. The exaggerated reports of the value of these discoveries, sent to San Francisco and other points on the Pacific Coast, led immediately to a rush of prospectors and miners to the territory; men who, in the majority of cases, had lived for years the rough life of mining camps, and were accustomed to little restraint except that imposed by the bowie-knife and revolver and the occasional administration of lynch law. A small mining town called Juneau City, after one of the original locators, was soon formed in the vicinity of the quartz ledges. While waiting for the winter snows to melt and expose the ledges sufficiently to allow prospecting, these men, who generally indulged in the most extravagant ideas of the richness of the country, wrought themselves into a high state of excitement over their prospects of wealth. The town was regularly laid out, town lots claimed and held at high figures, and conflicting claims, in some instances, soon led to threats of violence. Some of the miners, knowing the condition in which Alaska had been left so long by our Congress, without civil law or government, openly said "there is *no law* in Alaska," and proposed to exercise the law of individual might in settling cases where their claims were involved. In such a condi-

tion of affairs a slight spark might easily have produced an explosion of serious character, and it was manifestly the duty of the commander of the Jamestown to use the force at his disposal in the prevention of disturbances, and not wait for an actual outbreak before taking action.

For this purpose the miners and others were called together early in May, and after the condition of affairs had been explained, a proclamation was read and posted in a conspicuous place, putting all inhabitants, white as well as Indian, under military law for the preservation of order, the security of life and property, and the punishment of acts of violence. This proclamation, by its own terms, avoided interference with any rights to property already acquired, or to be acquired, or with any statutes in force, and was subject to the approval of the President.

Naturally, some opposition was manifested by the most turbulent portion of the small community to an innovation on mining camp procedure of so startling a nature, but the better disposed persons, who were in the majority, supported it, wisely regarding the military administration of justice as preferable to the irresponsible rule of Judge Lynch.

A reservation for government purposes was located in a position commanding the mining camp and the Indian village near at hand, and in a few days the miners saw the entirely new spectacle of a naval officer stationed among them with a force of blue-jackets and marines under his command sufficient to repress any disorder. The executive officer of the Jamestown, Lieutenant-Commander Charles H. Rockwell, was selected for this duty, and a force assigned him consisting of twenty-five officers and picked men, with a boat howitzer and a Gatling gun. Mr. Rockwell, by his cool and firm administration of affairs, under general instructions from the commanding officer, and the just settlement of many disputes referred to his arbitration, soon won the confidence of all, and the miners became rapidly accustomed to naval discipline. Affairs went on with the regularity and order of a well-disciplined man-of-war, and it was soon a subject of remark among the miners of longest experience that Juneau was the most orderly mining camp ever known on the Pacific Coast, while it enjoyed the singular good fortune of being one in which no murder was ever committed by a white man.

Subsequently, when in command of the steam sloop Wachusett, which vessel could easily reach the mining settlement at any time,

seeing that the desired effect had been produced, and needing the services of the officers and men on board ship, it was decided to withdraw the force from shore, and the community was so informed. The miners at once, without exception, united in a petition to have the naval force remain, even those who had in the beginning been loudest in their opposition, saying they preferred naval administration of justice to any other.

Although, as has been said, the Jamestown could do no cruising in Southeast Alaska, her influence was not confined entirely to Sitka and the mining camp, but was extended quite widely. By means of the steam launches, with which the ship was supplied when fitted out for this special service, many other points were reached, and in July, 1881, parties of officers and men were scattered about over nearly four hundred miles of coast line from north to south, engaged in keeping order and suppressing disturbances among the Indian tribes. This duty became much easier and was attended with far less exposure to officers and men when the Wachusett replaced the Jamestown on the station in August of that year.

Southeast Alaska consists of a narrow strip of coast, ten marine leagues in width, with innumerable islands, some of large size, separated from the mainland by narrow channels, and extends from the middle of Portland Canal, in latitude 54° 40′ North, to Mt. St. Elias, the initial point of the boundary line between the territory and British Columbia, which extends thence due north to the shores of the Arctic Ocean. It possesses a peculiarly equable climate, with an annual mean temperature much higher than found elsewhere in so high a latitude, due to the influence of the warm waters of the Kuro Siwo, or Black Stream of Japan, a portion of which, deflected by the Aleutian Islands, strikes the coast about Sitka. The thermometer rarely falls as low as 0° Fahr. in this portion of Alaska, and the lowest temperature recorded on board the Jamestown at Sitka in the winter of 1880–81, the thermometer being in an exposed situation, was only 19° Fahr., the mean for the three winter months being a little below 34° Fahr.

The natural conditions produce an excessive fall of snow and rain, and this, combined with the mild temperature, gives rise to a dense vegetation reaching everywhere from high-water mark to the snow limit on the mountains. The sides of the mountains, everywhere very steep, are covered with a dense growth of fir, spruce, alder, and cedar, with thick undergrowth that makes the country as impassable almost as a tropical jungle.

The timber is generally low in growth and not of much value, but in some of the valleys, especially on the larger islands, good timber is found in considerable quantities, the fir and a species of yellow cedar being the most valuable.

The fur trade of this portion of the territory is of no great value at present, the most esteemed furs being the sea otter and the silver-gray fox, but only a few skins are taken annually.

The fisheries are at present the most valuable resource of Southeast Alaska. Salmon of fine quality is found in the greatest abundance in all the streams, and has already become an important article of export, there being several large establishments where the fish is packed for the San Francisco market and for foreign trade. Halibut, cod, and herring are also very abundant, while all the small streams are filled with delicious trout.

No portion of Alaska will ever become useful for purposes of agriculture, and very little of the surface can be utilized for pasturage. From the shortness of the summer no grain will ripen, and the luxuriant grasses that grow so rapidly in the long mid-summer days cannot be properly cured for hay. A few potatoes of fair quality are produced at Sitka and at places to the southward, and in the gardens about Sitka and the other settlements there may be seen growing fine beets, turnips, cabbages, and cauliflowers, but other vegetables do not mature. No fruit is found growing anywhere in Alaska except a few varieties of wild berries.

Of the mineral wealth of Alaska very little is yet known, no sufficient explorations having been undertaken. Some of the quartz ledges about Juneau have proved to be valuable, and are now being worked successfully, and a considerable amount of gold has been obtained from placer claims. Of most of the discoveries of 1880, upon which such bright hopes were founded, but little more is known than at the time the original locations were made. The failure of Congress to provide any effective form of civil government for the territory, with the consequent doubt concerning the acquisition of valid titles, has deterred capitalists from engaging largely in mining operations, except in one case, where the venture has proved largely remunerative. The infrequence of mail communications, the distance from points of supply of mining machinery and appliances, and the great cost of transportation, have also contributed in a great measure to this result.

The disadvantages under which the territory has labored for so

long a time are now being remedied to a great extent, and as it becomes known, and its resources are developed, there is every reason to anticipate that the wisdom shown in the acquisition of Alaska will be fully demonstrated.*

*A more extended account of the climate, resources, and population of Alaska may be found in the valuable report of Mr. Ivan Petrof, published in Report of the 10th Census of the United States.

[COPYRIGHTED.]

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

POWDER IN GUNS.

[A continuation of "Velocities and Pressures in Guns," Vol. XIV, No. 2.]

By Lieutenant J. H. Glennon, U. S. N.

In a paper entitled "Velocities and Pressures in Guns," Vol. XIV, No. 2, the action of powder in guns was treated mathematically, with the tacit assumption of a certain premise which, though not new, being in fact the very foundation of Messrs. Noble and Abel's treatment of the work done by powder in guns, at first appears doubtful. The question is whether or not a progressive powder, if all burnt in a gun, and the gases produced have gained mechanical and thermal equilibrium by the time the projectile reaches the muzzle, will give as great a muzzle velocity, weight for weight, as a powder all of which is burnt before the projectile begins to move. This point can be elucidated in several ways, assuming, as in that paper, no radiation or conduction of heat to the gun or between the portions of the gas. In other words, the portions of gas are assumed to expand adiabatically.

One comment has been made and may be noticed here, namely: if, immediately around the surface of the burning powder grains, gas at high temperature and pressure exists, and the rest of the gas is, or may be considered, in thermal and mechanical equilibrium at a lower temperature and pressure, then the lower pressure, being that of the gas directly in rear of the projectile, would be the force accelerating it. Looking into the subject, however, we see that if only the low pressure exists at the base of the projectile, the high pressure must be somewhere else, as at the face of the breech-block; and if the low pressure may be considered by itself as accelerating the projectile in one direction, so may the high as accelerating the gun in the opposite direction. Newton's law on the equality of action and reaction would then not apply, remembering, of course, that the mean forward motion

of the powder gas (a motion partly action and partly reaction) is limited by the relative motion of the projectile and gun.

To proceed, suppose that we have a quantity of gas occupying a non-conducting cylinder $OMCD$, Fig. 1, that the pressure of this gas is represented in Fig. 2 by LB and the volume by OD. Interpose a non-conducting piston AB between the two halves of the volume of gas.

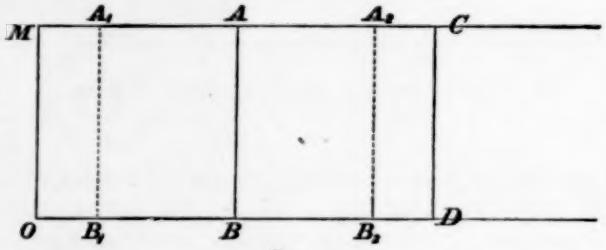


FIG. 1.

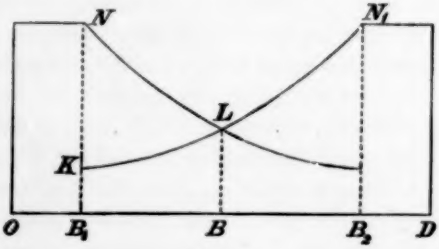


FIG. 2.

Now suppose that we push the piston AB to the position A_1B_1 (Fig. 1). The pressure of the gas to the left of the piston will increase from LB (Fig. 2) to NB_1, following the pressure-volume law $pv^n = p_0v_0^n$, where n equals $\frac{c'}{c}$, the ratio of the specific heats of the gas, or approximately 1.4. The work done in compressing the left half will then be represented (in proper units) by an area NB_1BL (supposing no friction). Part of this work, LBB_1K, will be done by the other half of the gas. The external work necessary to push AB to the position A_1B_1 will therefore be represented by NKL. If now the piston at A_1B_1 is released it will start towards AB, and when it reaches that position it will have a *vis viva* represented by NKL, will pass the position AB, and will then encounter retarding pres-

sures equal to those formerly accelerating it. It will be brought to rest at the position A_2B_2, determined by $BB_1 = BB_2$, will then return to A_1B_1, then back again, and so on, as long as there is no external work done.

Now connect the piston by means of a piston-rod, or otherwise, with the outside, so that it may do external work. It will come to rest when it has done the external work represented by NKL, and not until then. It will then be in its original position AB, and the pressure on each side of it will be the same as originally, so that if it were removed the gas would be in thermal and mechanical equilibrium.

Evidently, while the piston is in motion from B_1 to B_2, the cylinder head CD will be subject in succession to all the pressures represented by the ordinates of the curve KLN_1, and not alone to the pressure B_1K, with which the pressure to the right of the piston begins.

If now the mass of the piston is made smaller, its velocity at B will be increased, its mechanical energy or *vis viva* still remaining KLN. In the limiting case, where the mass of the piston is infinitesimal, its velocity will be infinite, the mean velocity for the travel of the piston will be infinite, and the distance B_1B_2 will be traversed in an infinitesimal time. Suppose that we take this limiting mass for the piston, and suppose, simultaneously with its release, that we release the cylinder head CD, allowing it free motion along OD, the mass of CD being supposed appreciable. Evidently CD will start under an accelerating force KB_1, and in an infinitesimal time will be subject to all the pressures KB_1 to N_1B_2. The piston AB will make an infinite number of vibrations in a short finite time, and will finally take up a mean position between O and D. The piston AB might then be removed, as, its velocity being finite, it will have no finite *vis viva*, the gas will be in equilibrium, and all the energy represented by NKL will have been transmitted to CD. The piston of infinitesimal mass of course does not exist; more properly a piston should be supposed which by its mass and motion would represent the mass and motion of the gas itself. In this case equilibrium would be gained, though not so quickly as with the infinitesimal piston. A little explanation possibly will be necessary to connect the assumed case with the case of fired gunpowder.

A charge of gunpowder is not all ignited at once. The particles of gas have a certain temperature and definite tension at the instant of combustion. Suppose a small quantity of the powder ignited

instantaneously, and suppose for the sake of simplicity, in lieu of other gas, that gas from just the same small weight of powder (expanded against pressure) already fills the powder chamber. The pressure of the last may be represented above by B_1K, and the pressure of the newly burnt powder by B_1N. The piston AB represents the outside surface of the last burnt powder gas, this gas being supposed to expand without loss of heat by radiation or conduction. CD represents the base of the projectile supposed free to move when the powder is burned. When the two parts of the powder gas are in equilibrium, the energy KLN will have been transferred from the last burned gas to the projectile. This will be in excess of the work that would be done by the same expansion in total volume, assuming both portions originally in equilibrium at the pressure LB. It will be the same with each successive portion, so that when all arrive at equilibrium the pressure will be the same as if the combustion of all had been simultaneous.

It is necessary to remember that the pressure of a gas is exerted equally in all directions, and that it does just the same quantity of work in expanding from one volume to another in all directions as in expanding in only one. The newly formed gas at the surface of the grain expands in all directions, and the vibrating piston AB ordinarily corresponds exactly with a vibrating spherical (oval or ring) surface around the grain, the gas inside of which finally gains equilibrium with the remainder of the gas in the gun.

In deducing the general equation ("Velocities and Pressures in Guns") of motion in the bore of a gun, a mean temperature T is assumed to exist in the gases, such that the pressure may be represented by $P = Rx\frac{T}{V}$. Now, while powder is burning in a gun no such equilibrium does exist, though the pressure P is fixed and definite; given P, we can very readily find a mean temperature for the gas if we solve this equation.

Given the work already done, we can also find a value for T. The question is, *when no equilibrium really exists*, are both answers the same, or should they be? To answer this let us look at Fig. 2. The pressure KB_1 would furnish the temperature of the expanded gas, and by subtracting this from the temperature of combustion of powder, the work already done, KB_1 would equal $Rx\frac{T}{V}$, where x is the weight of the expanded gas (as in "Velocities and Pressures in Guns"). Is

the pressure KB_1 that this T determines the accelerating pressure? No, unless all the powder gas is in equilibrium; as before stated, the accelerating pressure is a compound of all the ordinates from B_2N_1 to B_1K. If, however, no powder is burning, all the portions of gas being supposed at the same temperature and therefore the same pressure, it is. In other words, the general equation is true at any point if w, the weight of powder burned and in equilibrium, becomes constant at that point.

We assume, in mathematically treating this subject, that each elementary portion of the powder gas gains equilibrium in the element of time after burning. This is simply one way of saying that the powder gas gains equilibrium just as fast as it is evolved.

Imagine, to look at the subject in another way, the bore of a gun subdivided into a number of smaller gun-bores of equal size, and suppose each similarly loaded with its proportion of powder, the same for each of the smaller calibers. Now, imagine that these bores are so small that we can consider in each the combustion of the small quantity of powder contained as instantaneous. Further, suppose the bullets are of such different sizes that, though the small charges are ignited at different times, the bullets will all reach the muzzle of their respective barrels at the same time. Ignite the charges in succession, as determined by the size of the bullets. The pressure in each barrel at the muzzle will be independent of the time of arriving there, following the law $pv^n = C$, where C is some constant and will evidently be the same in all the barrels. The work done in each barrel will be precisely the same; and the total work for all the barrels will be precisely the same as if all the powder had burnt instantaneously in the original gun and then expanded to the muzzle. If now the size of the bullets be changed, the same equality will hold, provided that each bullet reaches the muzzle at the same time. There would then be an equilibrium of pressure throughout the gas if at the muzzle all the barrels were suddenly merged in one.

If, however, the bullets had not been properly proportioned there would be no such equilibrium, some of the projectiles would arrive late at the muzzle, and when merged the tensions throughout the gas would be variable. It is thus plain, if equilibrium is gained, that only one fixed quantity of work will be done for a fixed expansion of the same mass of powder gas (of fixed quality). Some light is thrown on the subject by Professor J. Clerk Maxwell in his "Theory of Heat" (edition of 1883), page 189, where he says: "If the system under

consideration consists of a number of bodies at different pressures and temperatures, contained within a vessel from which neither matter nor heat can escape, then the amount of energy converted into work will be greatest when the system is reduced to thermal and mechanical equilibrium by the following process.

1st. Let each of the bodies be brought to the same temperature by expansion or compression, without communication of heat.

2d. The bodies being now at the same temperature, let those which exert the greatest pressure be allowed to expand and to compress those which exert less pressure, till the pressures of all the bodies in the vessel are equal, the process being conducted so slowly that the temperatures of all the bodies remain sensibly equal to each other throughout the process.

During the first part of this process, in which there is no communication of heat between the bodies, the entropy of each body remains constant. During the second part the bodies are all at the same temperature, and therefore the communication of heat from one body to another diminishes the entropy of the one body as much as it increases that of the other, so that the sum of the entropy remains constant. Hence the total entropy of the system remains the same from the beginning to the end of the process. The work done against mechanical resistance during the establishment of thermal and mechanical equilibrium is greater when the process is conducted in this way, than when conduction of heat is allowed to take place between bodies at sensibly different temperatures."

The case of powder in guns as we are treating it is precisely similar to the case cited, with the exception that the 2d expansion does not take place, as the 1st will bring the portions of gas (treated as the above-mentioned bodies) to the same temperature and same pressure at the same time. But the entropy of the powder gas will determine its temperature at the muzzle, and therefore the work done; in short, it would determine the isentropic curve, according to which the gases would *finally* expand in the case of either instantaneous or progressive combustion.

M. Sarrau is probably correct in his statement that for any particular gun, charge, projectile, shape of powder grain, and material of powder, there is a size of grain that gives a maximum velocity, or that does in the gun the maximum amount of useful work. It is impossible, however, to discuss this maximum if we regard only primary causes. According to the most favorable treatment, the progressive

powder can at best only equal the instantaneous. The maximum powder then cannot be much better than any other powder completely burned and equalized in a gun. If the loss of velocity due to secondary causes is less with the progressive powder than with the instantaneous, we might expect the most progressive powder which can be completely burned in a gun to bring this loss to a minimum; in other words, the powder, all of which is completely burnt just as the projectile leaves the muzzle, cannot be far removed from the maximum powder. If then we make $\frac{l}{l_r} = KY_1 = 1$ (page 403, Proceedings U. S. Naval Institute, Vol. XIV, No. 2), and solve for r, we will have very nearly the time of burning of the grain of maximum powder in open air. All grains smaller than this will be of quick powders, all grains larger, slow powders, the other conditions of loading remaining the same.

M. Sarrau's method of finding the maximum powder by means of the first derivative of an empirical value of v (formula 15), which is true for slow powders only, is of course inadmissible. Generally now in guns maximum powders cannot be used, as the pressures would be too high.

Messrs. Noble and Abel really treat only of quick powders in guns. In finding the velocity due to powders of the same material, they use for any gun a certain factor of effect, which they multiply into the theoretical velocity (according to their method) due to the weight of the charge.

They tacitly assume as a fundamental principle, without question or attempt at proof, that the muzzle velocity of a certain projectile will be the same in the same gun if the weight of charge and the material are the same, no matter what the form or size of the grains may be. This of course can be true only when all of the charge is burnt in the gun.

M. Sarrau in his later works really treats, on the other hand, of slow powders only. From certain premises he obtains an equation of motion, equation 1 (p. 318, Proceedings Naval Institute, Vol. XIV, No. 2), and for w substitutes a function of the travel of the shot. When, however, w becomes equal to W, or when all the powder is burnt in the gun, it is plain that w ceases to be a function of the travel of the shot, it being then a constant. M. Sarrau's treatment then will not hold for quick powders or those which are entirely burned in the gun. In "Velocities and Pressures in Guns" it is

readily seen that M. Sarrau's velocity formula for slow powders is deduced and certain numerical functions calculated, identical in value with corresponding ones of M. Sarrau, starting with Messrs. Noble and Abel's fundamental principle for velocities with quick powders. The point of difference of these authorities is that each practically omits treatment of the half of the subject treated by the other, and that the value of the exponent n is assumed by M. Sarrau as 1.4, and by Messrs. Noble and Abel as slightly greater than 1.

Similar guns are those of which the bores are, or may be considered, similar right cylinders. They are similarly loaded when the volumes of powder chambers and the weights of the charges and projectiles vary as the cubes of the calibers, and the powder grains are similar in figure, their corresponding linear dimensions being proportional to the calibers. It is readily seen that "*in similar guns similarly loaded, the velocities and pressures corresponding to distances passed over proportional to the caliber are equal.*"

Taking formula (4), (page 400, Vol. XIV, No. 2, Proceedings Naval Institute), we see that the quantity in parenthesis is abstract, and the same for the same travel in two similar guns similarly loaded; it is readily seen that the term outside the parenthesis reduces to the same quantity in the two cases, when w equals W the full weight of charge; that is, when all the powder is burnt, as with quick powders.

For slow powders $w = WaKY_1(1 - \lambda KY_1 + \mu K^2 Y_1^2)$ (page 403, "Velocities and Pressures in Guns"); w for the two guns is *proportional* (in place of equal) to W, and the principle is proved for v as before. The proof for pressures is similar.

In the formula pv^n = a constant, which represents the instantaneous powder process, I will state that I do not consider $n = 1.4$ as final, or necessarily the best value; n is greater than 1 and probably not greater than 1.4. Tables could just as readily be calculated for 1.2 or any other value as for 1.4. This latter is simply true for the perfect gas. Nor is it certain absolutely that the velocity of combustion varies as the square root of the pressure (static). Any other power of the static pressure could be followed out just as readily, however, if further experiment should indicate another value. These values, however, lead directly to the best (probably) existing empirical formula for velocity, and therefore cannot be very far from the truth.

It then appears that the accelerating pressure when powder is burning in a gun is composed of two quantities, one of which we may

call the natural pressure, a static pressure corresponding, to take a familiar case, somewhat with the barometric pressure of the atmosphere; the other quantity depends on the rate of evolution of the powder gas, and corresponds almost exactly with the pressure on a surface due to a wind. Suppose a very low barometric pressure forward of a shell, a high barometric pressure in rear with a strong wind blowing directly into the chamber of the gun, and the case is not dissimilar to what really must take place when a progressive powder is burnt in a gun. When the powder is all burnt, to carry on the similarity, the wind will almost instantly die out and the gas will exert a pressure due to its weight, volume and temperature alone, a purely static pressure.

The quantity depending on the rate of evolution of the powder gas plays a still more important part with explosive compounds than with powder. If a finite quantity of explosive could be burned and equalized (as regards temperature and pressure) in an infinitesmal time, the pressure would be infinite. This is not realized, but is approached, when explosives are detonated. It undoubtedly partly, if not entirely, accounts for the great differences observed between the results of primary and secondary explosions of the same explosives.

It must be remembered that there are a number of different ways in which the subject of powder in guns may be treated, and in choosing any particular way the reasons that lead to that choice should be given. No theory or practice can make a progressive powder do more work than an instantaneous powder, though experiment seems to show that the former may do more of *useful* work. The theory chosen makes them equal as to work, and the experimental method of determining coefficients (by means of velocities in two guns) assumes them equal as regards *useful* work. In this latter the method is slightly in error. A factor of effect may be involved in the above-mentioned coefficients (A and B of formula (15) or M and N of (20), "Velocities and Pressures in Guns"). If this factor is found to vary slightly with the size of guns, the coefficients for any powder for a certain gun should be determined from guns of approximately the same size. For fairly approximate values of the coefficients to cover a number of guns of different sizes, guns of nearly the extreme sizes should be chosen. Dissimilar guns or dissimilar loadings should always be chosen, in order to make the ratios of the two terms of the formula as different as possible for the different guns, thus permitting a more accurate solution where the given quantities are at best only approximate.

Many powders now-a-days are not uniformly dense, being most dense on the surface and correspondingly slow burning, and least dense in the interior. If the velocity of combustion of powder varied inversely as the density, the formulas for velocity and pressure as deduced would apply equally well to these powders, provided that layers of uniform density were regularly arranged in the powder grains. This law, however, does not hold, and this fact may be expected to cause some error in the use of the formulas of "Velocities and Pressures in Guns."

It may be remarked that with slow-burning powders, such as is German cocoa powder when used in the 6-inch B. L. R., there is an interior layer in the grain that might as well be non-explosive, so far as giving velocity to the projectile is concerned.

A part of the work done by powder is done on the gun itself. In fact, the gun is only a projectile of certain mass (or virtual mass), and a pressure and velocity curve could readily be constructed for the travel of the gun while the projectile is in the gun, just as for the travel of the projectile during the same time. The work done on the gun in this way is of course small relatively, and taking account of it would generally be a useless refinement.

It may be stated, in closing, that no method dealing with pressures in guns as purely *static* can account for the velocities obtained. The pressures are *partly static*. The resistance to the projectile in air is quite similar to the pressure in the gun, and, as well as the resistance to a ship moving through the water, is very largely *dynamic*. The greater the velocity with which the explosive gas is evolved, the greater the pressure; just as in the air, the greater the velocity of the projectile (or the more quickly the air ahead is compressed and that in rear expanded), the greater is the resistance.

[COPYRIGHTED.]

U. S. NAVAL INSTITUTE, NEWPORT BRANCH,

JANUARY, 1890.

NOTES ON THE LITERATURE OF EXPLOSIVES.*

BY CHARLES E. MUNROE.

No. XXII.

United States Letters Patent No. 409943, August 27, 1889, have been granted Stephen H. Emmens for "Gun and Projectile for High Explosives," in which he claims to have invented "a new and useful improvement in apparatus for utilizing high explosives in warfare, (No. 2)." This invention is additional to his improvement in apparatus for utilizing high explosives in warfare,† set forth in his application for U. S. Letters Patent, filed January 27, 1888, serial No. 262172.

The present apparatus is especially designed and adapted for use by infantry and in small boats; and the invention consists in a novel combination of parts, whereby he claims to be enabled to lighten the apparatus to any required extent, and to support a relatively short powder-tube for the propelling charge within the guide bore of the torpedo by means of a tube in line therewith, that incloses the firing device, and is in turn supported by a simple stock in the form of a stake or the like. A drawing accompanies his specification representing an elevation of a torpedo-gun and a bird-torpedo, illustrating the invention.

The "firing mechanism," as he terms it, especially distinguishing the present weapon, comprises a wooden stock fitting into and sup-

*As it is proposed to continue these Notes from time to time, authors, publishers, and manufacturers will do the writer a favor by sending him copies of their papers, publications, or trade circulars. *Address Torpedo Station, Newport, R. I.*

† Proc. Nav. Inst. 15, 289; 1889.

porting a metallic tube, and axially perforated and slotted at its front end to accommodate within said tube a rod, which is bent at right angles at its rear end to form a trigger that projects outward through a bayonet-joint slot in the stock and tube. The front end of this rod is fixed in a piston which carries a firing-pin, and between said piston and the front end of the stock is a spiral spring; hence when the trigger is pulled back and turned into the holding-notch of the bayonet-joint slot, said spring is compressed, and when the trigger is released the spring urges forward the piston, with its firing-pin, to explode the propelling charge. This is contained within a short "gun-cartridge shell" or powder-tube, which fits into the front end of said tube and is coupled thereto by a pair of bayonet-joints. Preferably the "powder-tube," as it is termed, is provided with a primer-recess in its breech end, and with an axial ignition tube extending forward from said primer-recess to the front of the propelling charge, which may be of any suitable explosive. The ignition-tube is filled with gunpowder, and the recess is provided with a suitable percussion primer. When the latter is exploded by the firing-pin a sheet of flame is produced within the tube, which ignites the propelling charge at its front end, so as to insure its perfect combustion and an effective discharge of the weapon.

The bird-torpedo comprises a tube fitting closely over the metallic tube and powder tube above mentioned, and plugged at its forward end by the screw-stem of a conoidal torpedo-head. In an external annular charge-space immediately behind the head and around said tube, cartridges of emmensite, or other high explosive, are arranged side by side to form the high explosive charge. By using cartridges of different lengths the size of the charge may be varied to any required extent. These cartridges are held in position by a collar and a cylindrical jacket, and they are fired by a time-fuze. The rear end of the torpedo-tube is provided with three equidistant wings. An annular screen is fitted to the metallic tube of the torpedo-gun immediately in front of the trigger to protect the hand of the person discharging the weapon from any escape of heated gases.

The drawing shows the weapon planted in the ground for firing, but any other mode of mounting may be employed, *e. g.* the stock may be clamped in a holding-tube on an ordinary swivel stand or gunwale attachment.

In conclusion he claims as his invention: In combination with a thimble-shaped projectile having an axial guide tube open at its

rear end and surrounded by an annular charge-space for high explosives, a short powder tube and a tube inclosing a firing device, coupled together end to end and fitted to the interior of said guide tube, and a stock fitted at its front end to the rear end of said firing device tube, substantially as described.

The *Ann. des Mines* **5**, 197–376; 1888, contains a very valuable "Report of the French Commission for Explosive Substances on the Use of Explosives in Presence of Fire-damp," in which the authors state that having satisfied themselves, both from the results of previous investigations and in some preliminary experiments, that mixtures of coal-dust and air were not as dangerous as mixtures of marsh-gas and air, they have restricted themselves to the latter and more dangerous mixture. The experiments were conducted in a boiler which, by suitable arrangement, could be completely filled with a gaseous mixture of known composition, and the explosive under examination was suspended in the middle of the boiler and fired by the aid of electricity, the effect on the gaseous mixture being ascertained by the alteration in pressure observed on a pressure-gauge.

The marsh gas was prepared from sodium acetate and soda-lime and stored in a gasometer; it contained per cent 10.8 of air, 7.9 absorbed by bromine, no carbonic anhydride, and 81.3 of methane (by difference). The mixture introduced into the boiler contained generally about 10.3 per cent of methane; this approximates to the most explosive mixture, whilst a 6 per cent mixture verges on the limits of non-inflammability.

The first series of experiments were tried with unconfined explosives freely suspended in the gaseous mixture, this being the most dangerous condition; such experiments are useful to ascertain the actual safety of an explosive.

The explosives investigated were: *Ordinary powder; dynamite* containing 75 per cent of nitroglycerol and 25 per cent of silica; *Paulilles ammoniacal dynamite*, a mixture of varying proportions of nitroglycerol, ammonium nitrate, and of a carbonaceous substance destined to utilize the excess of oxygen produced by the detonation of the nitroglycerol and ammonium nitrate; *gun-cottons* of the general formula $C_{2n}H_{40-n}N_nO_{20+2n}$, in which the maximum value of n should be 12, but which in practice does not exceed 11. The following table represents the number of cubic centimetres of nitric

oxide evolved from 1 gram of the various gun-cottons when examined by Schloesing's method; the value of *n* indicates the composition:

	$n =$	cc. N_2O_2.
Endecanitric cotton, ...	11	214
Decanitric "	10	203
Enneanitric "	9	190
Octonitric "	8	178
Heptanitric "	7	162
Hexanitric "	6	146
Pentanitric "	5	128
Tetranitric "	4	108

Military gun-cotton (205 cc. N_2O_2) corresponds approximately to the decanitric; *mining gun-cotton* (193 cc. N_2O_2) to the enneanitric; and a third gun-cotton (173 cc. N_2O_2) investigated, to the octonitric. Tests were also made with *blasting gelatine* consisting of gun-cotton and nitroglycerol, and with *dynamite gelatine* consisting of blasting gelatine mixed with some such substances as a mixture of potassium or sodium nitrate with charcoal or sawdust. All these when detonated completely under the above conditions, generally ignited the gaseous mixture, and must therefore be regarded as dangerous for use in mines where fire-damp may be expected. The last two compositions did not detonate completely in cold weather. Dynamite and also gunpowder even ignited the gaseous mixture when detonated in a Settle's water-cartridge.* *Hellhoffite*, a mixture of dinitrobenzene with 1½ or 2½ times its weight of nitric acid (made on the spot where employed, but not considered sufficiently convenient for use in mines); *Favier's explosive*, 9 parts of mononitronaphthalene with 91 of ammonium nitrate; and *Bellite*, about 20 parts of dinitrobenzene and 80 of ammonium nitrate; either did not explode at all, as was the case with the first two when freely suspended in air, or exploded incompletely, as in the case of bellite. Under exceptional circumstances, finely pulverized Favier's explosive was made to explode and then ignited the gaseous mixture; but the detonating mixture used with this explosive is, however, of itself dangerous. Two powders consisting of gun-cotton and barium nitrate ignited the gaseous mixture, whilst a powder consisting of 60 parts of gun-cotton (175 cc. to 185 cc. N_2O_2), 30 parts of barium nitrate, 6 parts of saltpetre, 3 parts of gelose, and 1 part of paraffine,

* Proc. Nav. Inst. 14, 766; 1888.

only inflamed the gaseous mixture twice out of 14 times. Various experimental mixtures were now investigated. Dynamite with an equal weight of either crystalline sodium carbonate, sodium sulphate, ammonia alum or ammonium chloride, did not ignite the gaseous mixture, but with larger proportions of dynamite the ignition of the fire-damp generally ensued. Some interesting experiments were made with mixtures of coal-dust and dynamite. Three coals, containing respectively 40, 27.86 and 23.60 per cent of volatile matter, mixed with equal weights of dynamite, did not set fire to the marsh gas when exploded, even a mixture containing 4 of dynamite to 1 of the first coal in one experiment did not ignite it, but a mixture of 2 parts of dynamite with 1 part of a lignite (braunkohle) containing 62.4 per cent of volatile matter, ignited the inflammable gaseous mixture. Mixtures of 20 of dynamite with 80 of ammonium nitrate detonate freely in the air without causing ignition of the marsh gas; in this case both substances explode, but the temperature of the explosion of ammonium nitrate is lower than that of the dynamite, and therefore moderates the activity of the latter in the mixture. Mixtures of gun-cotton and ammonium chloride require so much of the latter to make them safe that they ultimately cease to explode at all. Mixtures of gun-cotton and ammonium nitrate become safe when the former, giving 173 cc. of N_2O_2, does not constitute more than 20 per cent of the mixture. From these experiments it was concluded that simple explosives susceptible of igniting fire-damp will always fire gaseous inflammable mixtures, but that it is possible to produce binary explosives in which the temperature of detonation is sufficiently reduced to be safe.

It is pointed out that, although the temperature of ignition of marsh gas is 650° C., the ignition is greatly retarded by admixture with another gas, such as air or even oxygen; the retardation amounting to 12 seconds even if the temperature of the whole volume of gas is at 650°, whilst at lower temperatures it is still longer. It is for this reason that the immense temperature developed by an explosion does not ignite fire-damp, for this temperature is reduced with such great rapidity, some thousandths of a second, that there is not time to ignite mixtures of fire-damp unless the initial temperature is sufficiently great, according to the observations of the present investigators about 2200° or over.

It is interesting to note that explosions not igniting fire-damp will ignite mixtures of coal-gas and air, these having a lower ignition point; and explosions igniting neither marsh-gas and air, nor coal-gas

and air, may ignite a mixture of hydrogen and air. The heat generated by explosives is next studied, and methods and formulae are given for its calculation.* Calorimetric experiments with various explosives freely suspended in the air yielded results, some of which are tabulated below.

	Weight of Cartridge, Grms.	Fulminate in Detonator, Grms.	Increase in Pressure after Explosion, Metres of Water.	Heat in Cals. for 100 grms. of Explosives calculated. From the Increased Pressure.	Heat in Cals. for 100 grms. of Explosives calculated. From Theoretical Data.
Dynamite	50	1.5	0.83	97.0	97.2
Military gun-cotton (205 cc. of N_2O_3)	50	"	0.72	88.0	104.0
Mining gun-cotton (193 cc. of N_2O_3)	50	"	1.48	172.0	103.0
Blasting gelatine (Paulilles),	40	"	0.56	80.2	153.5
" "	50	"	0.69	80.6	"
Bellite	50	"	0.28	32.7	100.2†
"	50	3.0	0.34	39.8	"
Pyroxylin powder (Moulin-Blanc)	50	1.5	0.60	70.0	82 dissoc. of $BaCO_3$.
" "	65	"	0.61	54.7	" "
58 gun-cotton + 42 barium nitrate	50	"	0.70	82.0	81 dissoc. of $BaCO_3$.
20 gun-cotton (173 cc. of N_2O_3) + 80 ammonium nitrate	50	"	0.15	17.5	80
25 " + 75 "	50	3.0	0.41	48.0	91
35 " + 65 "	50	1.5	0.43	50.0	102
60 " + 40 "	30	"	0.35	68.1	96
80 " + 20 "	30	"	0.63	123.0	82
90 " + 10 "	30	"	0.94	183.0	76
20 dynamite + 80 ammonium nitrate	50	"	0.225	26.4	50
67 dynamite + 33 ammonium alum	50	"	0.445	52.0	53‡
50 dynamite + 50 ammonium chloride	50	"	0.42	49.2	10‖
60 " + 40 "	50	"	0.44	51.5	35
67 " + 33 "	50	"	0.53	62.0	49

* Proc. Nav. Inst. 15, 306; 1889.

† Calculated for the proportions $175C_6H_4(NO_2)_2 + 825NH_4NO_3$.

‡ Allowing for complete combustion of the dynamite and simple dehydration of the alum.

‖ Complete combustion of dynamite, and decomposition of ammonium chloride into $HCl + N + H_3$.

Wherever the heats found coincide with the theoretical, complete detonation has ensued, and therefore these results confirm and explain the behavior of the various explosives already noticed. In explanation of the apparent anomaly of the lower nitrated gun-cottons giving higher temperatures than the more strongly nitrated ones, it is shown that the proportion of combustible gas in the gaseous mixture produced by the detonation increases as the proportion of nitrogen in the cotton diminishes; therefore the lower nitrated cottons should yield a more inflammable mixture which, by its combustion, would produce a great increase in temperature, and might even account for those temperatures which exceed the theoretical in the above table.

A similar behavior is observed with mixtures of gun-cotton and barium nitrate. A gun-cotton indicating by titration 180 cc. of N_2O_2 always ignites marsh gas, because the temperature of detonation, about 2000°, is increased by the combustion of the inflammable gas produced by the detonation; whereas the pyroxylin powder containing 60 per cent of this gun-cotton, 30 per cent of barium nitrate, and 6 per cent of potassium nitrate ignites marsh gas only exceptionally, owing, it is suggested, to the oxygen supplied to the mixture in the form of nitrates being sufficient to burn enough material so as to dilute the gaseous mixture produced by the detonation and render it non-inflammable; but by adding more barium nitrate, so as to provide enough oxygen to consume all the gas and admitting the subsequent dissociation of the carbonate, the temperature of detonation is raised to 2550°, which is sufficiently high to ignite fire-damp. With regard to force it is shown that the same amount of power may be produced at a lower price by the use of larger quantities of dynamite and ammonium nitrate than by employing smaller quantities of the more expensive dynamite.

Irregularities in explosives, such, for instance, as incomplete detonation, which produces indefinite reactions, are a source of danger, and are more common in mixtures than in simple explosives. These reactions vary under different circumstances, such as the amount of fulminate used for detonation, the temperature of the charge at the time of explosion, etc., therefore an explosive should not be considered safe if, amongst its several modes of detonation in the open air, there be one susceptible of igniting marsh gas. The most suitable substance for reducing the temperature of detonation of an explosive is ammonium nitrate, as other substances, such as sodium carbonate,

or sulphate, or alum, or ammonium chloride, only decompose partially and their effect is uncertain. Mixtures worthy of further consideration are: the pyroxylin powder; gun-cotton (173 cc. N_2O_2) with 80 per cent of ammonium nitrate, giving a force of 7550 grams and a detonating temperature of 1920°; dynamite, with 80 per cent of ammonium nitrate, $f = 6260$ grams, $t = 1500°$; bellite, $f = 2993$ grams, $t = 2186°$; Favier's explosive, $t = 2120°$. The last two require to be further experimented with. Ammonium nitrate reduces regularly, as the proportions of it in the mixture increases, both the temperature and power of dynamite and highly nitrated gun-cotton; but with octonitric gun-cotton these reductions do not set in until 70 per cent of nitrate is present. Curves illustrating this behavior are given in the report.

Experiments were now made with the more dangerous explosives confined in tubes of lead or tin, closed below and open at the top. The explosive was placed and rammed in the tube, on a plug of marl or sand 5 to 6 centimetres thick. It was then tamped with clay or sand, or, in some cases, coal-dust to the thickness of 10 to 12 centimetres. Tubes of various thicknesses were used and exploded, as in the previous experiments, in the boiler. The portion of the tubes surrounding the explosive was blown to powder, whilst the upper and lower portions were generally found nearly intact at the bottom of the boiler. The following table of results illustrates the effect of the thickness and quality of the tube on the temperature of explosion.

Explosive.	Description of Tube. Diameter. Internal. mm.	Diameter. External. mm.	Material.	Effect on Mixture of Marsh-Gas and Air. I = Ignition, N = No ignition.
Dynamite, ...	27	40	Lead	N.
"	30	40	"	I.
"	30	35	"	I.
"	25	40	Tin	N.
Mining gun-cotton, . .	32	42	Lead	N.
" " . .	30	35	"	N.
Blasting gelatine, . . .	25	40	Tin	I.
Dynamite gelatine, . . .	27	40	Lead	N.
Ammoniacal dynamite, .	25	40	Tin	N.

Other conditions being the same, the safety of the explosive increases with the thickness of the tube, owing, it is assumed, to the

fact that much of the heat of detonation is converted into mechanical force, and so the temperature is reduced below the dangerous limit. Dynamite loses more than one-third of its initial heat of detonation in shattering the tube and distributing the debris. To ascertain the effect of the density of a charge, the explosive was enclosed in a thin glass tube and fixed by wads between the clay plug and tamping in the metal tube so as to leave an annular space between the metal sides of the tube and the exterior of the glass tube. Under these circumstances it was observed that the work done on the tube was greatly diminished, owing, it is suggested, to the expansion of gases within the tube, and instead of one-third, only one-fifth of the initial heat of the detonation of the dynamite was absorbed. The same result is observed with loosely packed explosives; for example, dynamite simply poured into a 32–42 mm. lead tube and tamped, ignited fire-damp, whereas under the same conditions with the dynamite rammed in, no ignition ensued. This shows the importance of ramming and tamping well when using explosives. Altering the shape of the tube simply varies the work imposed on a unit volume of gas, the larger the proportion of surface the greater the imposed work, but does not affect the density of the charge. Further experiments show that dynamite alone or mixed with 80 per cent of ammonium nitrate, or 33 per cent of ammonia alum, or 40 per cent of ammonium chloride; bellite; pyroxylin powder (Moulin-Blanc); and gun-cotton (173 cc. N_2O_3) mixed with even 40 per cent of ammonium nitrate, explode completely when confined in 25–40 mm. tin tubes, bellite even in a 30–35 mm. lead tube; but blasting gelatine requires a stronger tube to ensure its complete detonation.

With regard to modes of igniting the charge, when a fuze (Bickford) is used, care must be taken not to place it in contact with the explosive, for under such circumstances gas and flame may be projected through the tube into the external air, and so produce ignition of the fire-damp. Other objections to the Bickford fuze are the uncertainty of its composition and the danger attached to lighting the exposed end. When electricity is used, preference should be given to currents of low tension, so as to avoid sparking and possible ignition of fire-damp. Detonating cords made of gun-cotton have been found uncertain. Lauer's friction cap has not yet been investigated by the Commission. Various detonators have been examined, and, with the exception of those of Ruggieri and Scola, and ordinary 1.5-gram fulminate caps, they do not ignite mixtures of marsh-gas and

air when exploded by themselves. Strengthened fulminate caps differ from the ordinary ones chiefly in being made of stouter metal and having the fulminate more compressed, and covered by a little metallic plate with a hole in the centre to allow access of fire; the gases from the explosion of these caps have, therefore, more work to do, and lose temperature, and consequently a strengthened 1.5-gram cap, as might be presumed by the above hypothesis, does not ignite a mixture of marsh gas, or even coal-gas and air, but does ignite a mixture of hydrogen and air; a larger charge, however, 5 grams for instance, produces sufficient heat to ignite fire-damp. By imposing more work on the gases of detonation of an ordinary fulminating cap, a similar effect is produced. Thus, by winding fine copper wire closely round the outside of an ordinary 1.5-gram cap, this ceases to ignite fire-damp when detonated.

The conclusions arrived at have already been mentioned above, but special stress is laid on the importance of making the explosive do as much work as possible; and bearing in mind the uncertainty attached to the use of even the safest explosives, and the advisability of avoiding their use in presence of inflammable mixtures of marsh-gas and air, the selection of the safest explosive "ought to be considered as diminishing the danger of explosion considerably, but it ought not to be regarded as suppressing it absolutely."

Binary mixtures of ammonium nitrate with dynamite or gun-cotton or dinitrobenzene are recommended from a point of view of safety, although it is suggested that experiments should be made on the method of manufacture of these mixtures, on their durability, and on their behavior in mines. All the results of the numerous experiments are tabulated, and notes containing interesting theoretical considerations are appended, in which methods of calculating the force and temperature obtainable from explosives are given, and the results of such calculations are also tabulated. An objection to the use of water cartridges is the large bore-holes required.

Subsequent to the drawing up of the above report further experiments were made, using a mixture of coal-gas and air, thus avoiding the expense of the manufacture of marsh gas. The most explosive mixture of coal-gas and air contains 15 to 16 per cent of the former. In the experiments it was more convenient to use a mixture containing 10 per cent; the ignition temperature of this mixture appears to be about 2100°. This was ascertained in the same way as the ignition temperature of marsh-gas and air, namely, by exploding in it

various cartridges of which the temperature of detonation, etc., could be calculated, the cartridge giving the lowest temperature and igniting the mixture being the one selected for fixing roughly the ignition temperature of the mixture. This mixture of gas and air is not much more inflammable than marsh-gas and air; therefore it is considered that it would not be too severe a test to make all explosives destined to be employed in presence of marsh gas satisfy the condition of not igniting such a mixture of coal-gas and air when detonated while freely suspended in it.

In the first report it was suggested that the moisture of the atmosphere aided the explosion of fire-damp, but further experiments have not confirmed this suggestion.

The statements regarding dynamite are not altered in the second report, but as regards gun-cotton it is shown that, although the gases from octonitric cotton burn in the air when the cotton is exploded unconfined, nevertheless when this explosive is confined in a tin tube, 25 mm. internal diameter, 31 mm. external, or thicker, not only does the gas not burn, but also the detonation is incomplete. By testing mixtures of dynamite and ammonium nitrate containing from 90 to 40 per cent of the latter, it is shown that the detonating power increases as this proportion decreases, and complete detonation of the unconfined mixture does not take place until 50 per cent of dynamite is reached; even increasing the amount of fulminate used with the 20 per cent dynamite mixture scarcely improves the extent of detonation. In a 25 mm. by 31 mm. tin tube the condition of affairs is not much better, but in a 25 mm. by 40 mm. tin tube complete detonation of both dynamite and nitrate ensues. The gases evolved from this mixture do not react on one another; the same is the case with mixtures of dynamite and alum, ammonium chloride, etc. It is suggested that in such mixtures the non-explosive constituent, the one absorbing heat on decomposing, is decomposed only slightly, or not at all, during the propagation of the explosive wave, their decomposition only taking place in a closed tube. Various mixtures giving gases which react on one another were examined, such as mixtures of ammonium nitrate with combustible substances, gun-cotton, dinitrobenzene, ammonium picrate, naphthalene tar, heavy coal-oils, colophony, etc. In the open air they behave sometimes as if the explosive wave, excited at one point, exhausted itself before traversing the whole mass of the explosive; at other times, as if the explosive wave passed through the whole mass of the explosive, but stopped

at the decomposition of the explosive constituent or constituents, the gases evolved being dispersed before reacting mutually; therefore the detonation in the open air is incomplete. When, however, the gases are confined, as, for instance, when the explosive is put in a sufficiently strong metal case, then the reaction between the gases takes place, and the effect of a complete detonation is obtained. There are numerous results, tabulated, illustrating these points. Mixtures of about 80 per cent of ammonium nitrate with gun-cotton, or 83 per cent with dinitrobenzene, do not detonate completely either in the air or in thin (25x31 mm.) tubes, but do in 25x40 mm. tubes. Mixtures of ammonium nitrate and picrate in the open air give an effect equal to the decomposition of the nitrate, but in the tube the result is equal to the decomposition of both. With tars, etc., the result is never much above that attributable to the ammonium nitrate.

Experiments were now made with increasing quantities of safety mixtures to test their capability of igniting the inflammable gaseous mixture; the various results are tabulated and discussed. In the following table is given various data relating to the mixtures which proved safe; other mixtures already referred to are either too expensive or inconvenient, or improper as explosives, as far as the present results indicate.

	Force in kilos.	Heat from 1 kilo in cals.	Grms. of Fulminate required for Detonation.
Dynamite (for comparison),	8.490	1.109	...
30 of dynamite, 70 of ammonium nitrate,	6.750	.600	0.50
20 " 80 " "	6.260	.530	0.50
20 of gun-cotton,* 80 of " "	7.610	.810	1.50
15 " " 85 " "	7.000	.700	1.50
12½ of dinitrobenzene, 87.5 " "	8.000	1.006	1.50
10 " " 90 " "	6.700	.750	1.50

Other mixtures worthy of consideration are those containing mononitronaphthalene, or naphthalene, and ammonium nitrate, but their behavior is at present uncertain. Finally, attention is called to mixtures of ammonium copper nitrate and ammonium nitrate. The heat of formation of this salt $N_2O_5CuO, 4NH_3$ is for ($N_6 + H_{12} + O_5 + CuO$) 164.1. The products of decomposition have not been studied, but the mode of disengaging most heat is as follows:

$$N_2O_5CuO, 4NH_3 = 3N_2 + H_2 + 5H_2O + CuO,$$

* About octonitric.

disengaging 516 cals. per kilo. When exploded in the air, white fumes of ammonium nitrate and of oxides of nitrogen are evolved; therefore the products are uncertain. Its complete combustion by ammonium nitrate is represented by the following equation:

$$Cu(NO_3)_2, 4NH_3 + NH_4NO_3 = 4N_2 + 8H_2O + CuO,$$

or proportions of 76 to 24 of nitrate, heat produced per kilo = 655.5 cals., whilst the force = 6.090 kilos, and temperature of detonation 1750°. This was therefore considered as an interesting explosive in connection with safety in fire-damp. In the open air or in tubes the detonation of the salt does not appear complete according to the above equations, either alone or when mixed with ammonium nitrate; in fact, is almost arrested in the open air when the nitrate present is double the copper salt. It is believed it would explode completely in a mine bore-hole; with regard to its safety the results are very satisfactory, even with mixtures containing only 25 per cent of nitrate, but the mixture containing 80 per cent of nitrate is safe in coal-gas, detonating at a temperature of 1300°, with a force of 5500 grams.

In conclusion they point out that safety mixtures of dynamite and ammonium nitrate should not contain less than 80 per cent of the latter. The other mixtures must fulfill the conditions of having a temperature of detonation lower than 2200°, of not yielding combustible gas after complete detonation, of having sufficient force to avoid use of larger quantities of the explosive, of being sufficiently explosive to minimize missfires, of being kept sufficiently long without undergoing change, and they must not be too expensive. Mixtures fulfilling these conditions more or less are those with ammonium nitrate, and (1) a maximum of 75 per cent of ammonium copper nitrate; (2) 6 per cent of naphthalene; (3) 15 per cent of octonitric gun-cotton; (4) 10 per cent of mononitronaphthalene; (5) 10 per cent of dinitrobenzene. They recommend trials of these in mines.

To avoid danger as much as possible, the mixtures should be well mixed, and the smallest proportion of the dangerous substance, consistent with efficiency, should be used.

As safety depends on the instantaneous admixture of the gas of the detonation with the surrounding atmosphere, it is therefore dangerous to blast with a large quantity of explosive in a confined space.—*J. Soc. Chem. Ind.* **8**, 415–419; 1889.

H. Lohmann, in *Zeits. f. Berg., Hütten- und Salinwesen* 83; 1889, gives a "Report on Further Experiments with Explosives at the Experimental Level of the König Colliery, near Neunkirchen (Saarbrücken), in Respect to their Behavior with Fire-damp and Coal-Dust," in which he states that *an explosive* consisting of a mixture of dynamite with 40 per cent of soda crystals gave very good results, both as regards safety from colliery explosions and the production of large coal. Samples of "carbonite" gave better results than before, and the cartridges were better made. Water cartridges—the explosives surrounded with water—gave good results as to safety.

"Ammonia dynamite" consists of 40 per cent of ammonium carbonate, 10 per cent of nitre, and 50 per cent of a mixture of nitroglycerol and kieselguhr, containing sufficient of the latter to make the mass plastic but not too soft. The introduction of ammonium carbonate is less advantageous than the oxalate. A good mixture is 45 per cent of ammonium oxalate, 15 per cent of nitre, and 40 per cent of the kieselguhr dynamite. It seems possible that by some alteration in the composition of ordinary black powder it may be possible to use it in collieries with safety, ammonium oxalate being used in place of carbon.

"Securite" gave bad results as regards safety from explosion. The Rottweil powder works has consequently much altered and greatly improved this explosive.

"Roburite" was used with success in workings which were free from fire-damp. Analysis failed to show the presence of chlorine in the explosive obtained from Witten, although it was supposed that some of this element was present.

As regards risk from explosion, "ammonia dynamite" proved to be very safe; "kieselguhr dynamite" and "gelatine dynamite" were bad and about equally so; "roburite" is better than "gelatine dynamite," but not so good as "ammonia dynamite," although it is possible that this explosive may have been recently still more improved. "Carbonite," the improved "securite," and "soda dynamite" afford great safety. "Gelatine dynamite No. 2" is as good as "No. 1," and Favier's explosive, one sample of which consisted of dinitrobenzene, mononitronaphthalene, ammonium nitrate and nitre, also gave very good results.—*Loc. cit.* 419.

English Patent No. 9164, June 23, 1888, has been granted T. G. Hart for "Improvements in Explosives for Use in Firearms," which

claims a form of gunpowder consisting of compressed potassium chlorate, granulated, and permeated "with a saccharine solution or other suitable hydrocarbon liquid."

Silesit is the name given to an explosive for which Austro-Hungarian Letters Patent No. 2219 were issued November 12, 1887, to Drs. Pietrowicz and Siegert. It consists of potassium chlorate 60 parts, antimony sulphide 10 parts, and sugar 30 parts.

English Patent 13789, Sept. 24, 1888, has been granted T. M. Justice for "An Improved Explosive Compound."

This invention relates to an explosive composed of "a suitable nitrate" coated with a hydrocarbon, such as paraffine or naphthalene, and rendered sensitive to detonation at the desired time by admixture with potassium chlorate.—*Jour. Soc. Chem. Ind.* **8**, 818; 1889.

English Patent 11102, July 10, 1889, has been granted W. H. A. Kitchen and J. G. A. Kitchen for "A New Explosive."

This invention relates to a mixture of chlorate of potassium, coal dust, and resin or sulphur.

We have previously noted that when picrate of potash is used in rockets and bombs a curious whistling sound is produced.* U. S. Letters Patent No. 411714, September 24, 1889, have now been granted Antonio del Grande for "Preparing Pyrotechnic Compounds," in which he claims the method of preparing potassium picrate by reacting on a solution of picric acid with magnesium carbonate, and mixing with this an aqueous solution of potassium nitrate, by which potassium picrate is precipitated.

English Patent 13360, Sept. 15, 1888, has been granted T. Chandelon for "Improvements relating to the Manufacture of Explosives," the chief feature of the invention being the use of organic picrates, together with nitrates, or chlorides or both, to form an explosive compound.

Mixtures are described of picrate of benzene, picrate of nitrobenzene, picrate of dinitrobenzene, and picrate of nitronaphthalene with nitrate of ammonia or other nitrates; also of mixtures of the above picrates in which the nitrate has been replaced wholly or partly by a chlorate.

* Proc. Nav. Inst. 15, 85, 86; 1889.

H. von Asboth proved the "Presence of Pyridine in Amyl Alcohol," *Chem. Zeit.* 13, 871–872, by dissolving picric acid in the alcohol, when crystals of what proved to be pyridine picrate crystallized out. These crystals melt at 144.5°, and are decomposed by strong acids or bases with the separation of pyridine. Heated gently, they are partially decomposed; strongly heated, they decompose. Their formula is $C_5H_5NC_6H_2(NO_2)_3OH$.—*J. Soc. Chem. Ind.* 8, 134; 1889.

English Patent 370, January 10, 1888, has been granted S. H. Emmens for "The Preparation of Certain New Compounds from Picric Acid, and the Manufacture therefrom of Explosives, partly applicable also to Colored Fires."

The crystals deposited, after treatment of picric acid with red fuming nitric acid of sp. gr. 1.52, are called by the inventor "Emmens" acid, and are an ingredient of his explosives.

The liquor remaining after the deposition and removal of these crystals will yield a second crop of similar crystals, and will deposit simultaneously a quantity of lustrous flakes. These flakes, heated in water, separate into two new bodies, one of which enters into solution and forms crystals unlike the above, while the other body fuses and remains below the water undissolved.

These acid crystals and residuum are also used as ingredients of the explosives and a mixture of "Emmens" acid, and these two new bodies are called "Emmens" mixture. Explosives are formed by fusing "Emmens" acid to a nitrate together, or "Emmens" mixture and a nitrate, and such explosives are called "Emmensite." The mixtures have to be exploded by detonation.

English Patent 10722, July 24, 1888, has been granted A. Nobel for "Improvements in Explosive Compounds." This invention relates to the manufacture of an explosive consisting of nitrate of ammonia and picrate of ammonia in the proportion of three parts of the former to one part of the latter.

Gum arabic, dextrin, or an analogous substance is added in the proportion of about ½ per cent of the material, with a view of hardening it.

English Patent 6560, May 2, 1888, has been granted A. Nobel for "Improvements in Explosive Compounds." This invention relates to the treatment of nitrated starch and nitrated dextrine for the production of explosive compounds to be used in place of gunpowder.

For this object nitrated starch or nitrated dextrine is incorporated with nitrocellulose, and both dissolved in a suitable solvent, such as acetone, etc. By means of such solvents, which are afterwards distilled off and recovered, a very perfect incorporation can be brought about.

Other explosive substances or oxidizing agents, such as picrates, chlorates, nitrates, etc., may be incorporated with the aforesaid materials, the quantity of the solvent being so far increased as to allow of a complete and uniform distribution of the substance to be incorporated.

U. S. Letters Patent No. 411127, dated Sept. 17, 1889, have been granted Hudson Maxim, of Pittsfield, Mass., for a "Method of Producing High Explosives."

The object of this invention, as stated, is to prepare a high explosive in a form so that, while retaining all the explosive power of its constituents, it will be in such a compact, solid, and therefore stable condition as will permit it to be readily and safely handled and will adapt it to be projected from ordnance with gunpowder; that is to say, it is the purpose to prepare the explosive so that it may be packed in shells and other projectiles and safely fired from guns as shells charged with ordinary gunpowder are commonly fired.

To this end the invention consists in dissolving gun-cotton or nitrocellulose in a proper solvent which is capable of being evaporated, adding to the dissolved nitrocellulose nitroglycerine, and then evaporating the volatile solvent from the mixture.

In carrying out his invention he first thoroughly dissolves gun-cotton in the solvent, which usually will be a liquid, such as acetone or ethylic acetate, or a mixture of sulphuric ether and alcohol. A sufficient quantity of the solvent will be employed to thoroughly reduce or dissolve all, or practically all, of the gun-cotton. The nitroglycerine will then be added and thoroughly incorporated with the dissolved nitrocellulose. The product thus produced is now to be spread out and the volatile solvent evaporated therefrom, the residue being a comparatively hard, dense, and rigid mass, the components of which are maintained in a stable and safe condition. He claims that this explosive has all the high power of gun-cotton or nitrocellulose and of nitroglycerine, cannot readily be exploded by concussion, and may be worked and shaped for the purpose of charging shells or projectiles. The presence, however, of the nitroglycerine

in the explosive renders it capable of being exploded by ignition or by a detonating charge of fulminate of mercury, or by electricity. The quantity of nitroglycerine, however, is not sufficient to make it susceptible of exploding by any ordinary form of concussion, such as it would be subjected to in handling or in being discharged from a gun with gunpowder.

The quantity of nitroglycerine in the explosive will, of course, depend upon the desired sensitiveness of the compound, and, accordingly, as the explosive contains more or less of nitroglycerine will it be necessary to employ a detonator of less or greater energy. In practice the object will be to add only such quantity of nitroglycerine as will insure the proper instantaneity of explosion.

He states that other solvents may be employed, such as vapors of various liquid solvents or a partially dry solvent; or even a dry solvent may be used, such as camphor; and he therefore does not limit himself to any special form or kind of solvent. So, also, the nitroglycerine may be mixed with a solvent capable of dissolving the nitrocellulose, and the latter be dissolved in conjunction with the nitroglycerine.

Aware that gun-cotton has heretofore been reduced to a very tough, dense, and solid mass by solvents, he does not claim such process, as the explosive thus produced has not the capacity of exploding with the certainty of his explosive, as he states, and that it has not the proper degree of sensitiveness to the detonating charge, and the instantaneity of its explosion depends largely upon the conditions of its confinement. He is also aware that gun-cotton has been dissolved in nitroglycerine, thus producing what is known as "nitrogelatine"; but this is not his process, for the resulting explosive is an unstable jelly-like mass, very susceptible of explosion, while his explosive has all the advantages of those last named products with none of their disadvantages.

He does not claim therein the compound produced by the process described, the same being previously claimed in his application, Serial No. 318670, filed July 25, 1889, but desires to reserve his right to claim said compound.

What he claims as new is:

1. The herein described process of producing high explosives, consisting in dissolving gun-cotton or nitrocellulose in a suitable solvent, adding to the dissolved nitrocellulose nitroglycerine, and then evaporating from the mixture the volatile solvent.

2. The process herein described for manufacturing explosives, which consists in dissolving nitrocellulose in a volatile solvent, combining therewith nitroglycerine, and evaporating the volatile solvent therefrom after the admixture of the nitroglycerine.

Austro-Hungarian Patent No. 2387, November 25, 1887, has been granted D. Johnson for "Gunpowder from Nitrocellulose." For sporting powder the mixture consists of dinitrocellulose 68 parts, barium nitrate 25 parts, potassium nitrate 6 parts, and ultramarine 1 part. These are mixed with water, corned and dried, and they are then treated with a mixture of camphor 10 parts and benzene 50 parts, when they are warmed to about 100° C., to convert the whole.

For military powder the proportions are dinitrocellulose 35 parts, barium nitrate 60 parts, and charcoal or lampblack 5 parts.

English Patent No. 14027, September 29, 1888, has been granted C. O. Sundholm for "Improvements in the Manufacture of Dynamite." The object of this invention is to render dynamite not liable to injury or deterioration by water or moisture, and even capable of acting effectively whilst immersed in water. The invention consists in employing as the absorbent of the nitroglycerine the substance obtained by carbonizing without access of air, a siliceous earth naturally containing organic or carbonaceous matter.

According to the *Journal Chemical Industry* **11**, 350–352, Romite, which is the invention of a Swede (Sjöberg), is prepared, according to one method, by treating 10 parts of ammonium nitrate and 7 parts of potassium chlorate with a solution of 1 part naphthalene in 2 parts of rectified paraffine oil. Among the advantages claimed for romite is included safety in manufacture, transport and use, but the writer of this article calls attention to the widely known fact that chlorate compounds constitute unsafe and unstable explosives, and refers to the spontaneous ignition of some romite whilst being conveyed from Sweden to Germany for experimental purposes, under the superintendence of the inventor himself.

English Patent 7497, May 22, 1888, has been granted H. J. Allison for "Improvement in Explosive Compounds," the object of which is the production of a blasting powder, to consist of a mixture of ordinary granulated black blasting powder with nitroglycerol, which shall preserve the granular form and structure of the former and not be

reduced to a pasty, sticky or deliquated mass during mixing. This is effected by mixing starch paste with the materials of the black blasting powder (charcoal and a nitrate), when on drying and granulating this powder possesses a cellular or honeycombed structure, and readily absorbs nitroglycerol while retaining its full granular form.

A Swedish engineer, J. W. Skoglund, has invented a new explosive which he calls Grakrut. According to the official reports this gray powder has been used with 25 millimeter as well as with Nordenfelt's machine guns. The former, with 70 per cent of the new powder against 100 per cent (or the usual charge) of ordinary powder, gives 33 per cent greater initial velocity, without the pressure in the gun being increased more than 5 per cent. With 62 per cent (ordinary charge weight) of gray powder, the initial velocity was increased 24 per cent without any perceptible increase in pressure. With a charge of 74 per cent (ordinary charge weight) the initial velocity was increased 40 per cent without the gun being subject to any undue pressure. With regard to the important question of smokelessness, the report states that while with Nordenfelt's machine guns smoke of ordinary powder remains for twenty-five seconds, the gray powder only leaves a transparent steam, which is only visible for five seconds.—*Sci. Am.* **312**; 1889.

English Patent 14623, November 11, 1886, amended October 5, 1888, has been granted C. E. Bichel for "Improvements in the Manufacture of Explosive Compounds."

The inventor prepares a "cheap and harmless explosive" by first sulphurizing resin oil or other hydrocarbons, such as wood or coal-tar or their distillates boiling between 120° C. and 200° C.; secondly, mixing the above with nitrates or chlorates. He also employs the above sulphurized hydrocarbons mixed with nitrobenzene, nitrophenol, nitrotoluene, etc., and with explosive nitro-compounds such as nitroglycerol and nitraniline, in order to render these latter more stable.

The sulphurizing is carried out by distilling the hydrocarbons in combination with sulphur, and it is claimed that the compounds resulting from the above treatment "exhibit the peculiarity that they mix readily with nitro-compounds, whilst in the case of the products of distillation not sulphuretted, even when they appear to mix, a subsequent separation takes place which renders the production of a stable product impossible."

English Patent 11751, August 15, 1888, has been granted C. Lamm, the object of the invention being to protect and preserve explosives which contain hygroscopic salts.

In carrying this out, carnauba or other palm wax is employed mixed with Japan wax, naphthalene, paraffine, etc., as a waterproof coating for the explosive when made up into blocks or cartridges.

English Patent 12424, September 13, 1887, has been granted E. D. Müller for "Improvements in Explosive Compounds," in which the patentee proposes, in order to cool the explosive gas mixtures, to mix various explosives, such as nitroglycerine, with 15–65 per cent of salts containing more than 5 molecules of water of crystallization, preferably soda crystals, the alums, the sulphates, etc. of sodium. These mixtures are formed into cartridges, and at the explosion, the water being converted into steam, cools the gases down to such an extent that an absolute security against the ignition of the explosive gases is obtained. For warm climates magnesium sulphate is preferable to soda crystals or Glauber salt, and different mixtures and salts are selected according to the advantages they offer in special cases.

English Patent 16920, December 8, 1887, has been granted A. Nobel for "An Improved Explosive Compound." The inventor finds that ammonio-nitrate of copper ($4NH_3Cu(NO_3)_2$) possesses explosive properties, and although it cannot be fired by a spark or Bickford fuze, it develops great energy when detonated.

The ammonio-nitrate of copper is not sensitive to concussion. It is claimed that a very short flame of comparatively low temperature is emitted on detonation, not capable of igniting fire-damp under conditions where gunpowder or dynamite would cause it to explode.

It can be used for propelling projectiles after it has been granulated in the same manner as gunpowder is granulated, but has to be fired by a special primer of gunpowder. In filling cartridges for firearms with granulated ammonio-nitrate of copper, the gunpowder primer is so arranged as to be fired directly by the cap, and then the charging is completed as with ordinary gunpowder.

For use in mines it is simply filled into ordinary paper cartridges and fired by a detonator.

English Patent 5061, April 5, 1888, has been granted H. Müller for "Safety Fuze and Igniting Apparatus for Setting Fire to Explo-

sive Charges without Danger from the Presence of Fire-damp," which is effected by means of an envelope of wire, gauze, or similar material fixed on to the tube in a special way.

English Patent 5624, April 16, 1888, has been granted C. A. McEvoy for "Improvements in Fuzes," the object being to form a fuze that will be ignited by immersion in water. This is effected by means of sodium or potassium, or a mixture of both, suitably attached to the fuze.

U. S. Letters Patent No. 414662, November 5, 1889, have been granted Franz L. and Hans Firmann for a "Percussion-Fuze for Blasting." This invention relates to fuzes for blasting and like purposes (such as the firing of cannon) wherein the primer or explosive is exploded by being struck by a hammer.

It provides a percussion fuze which can be safely transported, handled and used. The hammer is normally partly retracted, being so held against the tension of its spring by a safety stop which prevents it moving forward far enough to reach the primer. When the pull-wire is pulled the hammer is drawn fully back, the spring fully compressed, and on increasing the pull the wire is disconnected, so that the hammer is released and flies forward against the primer.

U. S. Patent No. 408096, July 30, 1889, has been granted W. H. Frazer for a "Cap for Fuzes," the cap being made of rubber partially vulcanized, but yet sufficiently flexible to be slipped over the end of a fuze. The inventor seeks by this means to avoid the danger which attends the fixing of the ordinary metallic blasting cap on the leading fuze by the usual method of crimping.

In the "Report of Committee of the Society for the Protection of the Interests of Chemical Industry in Germany," it was proposed, on behalf of the percussion-cap manufacturers, that *denaturized spirit* be mixed with 0.025 per cent bone-oil or 0.5 per cent oil of turpentine, and, in any case, with 0.025 per cent pyridine bases, for the production of fulminating mercury, to the exclusion of wood spirit, which lowers the yield and deteriorates the quality of the product. According to the proposal, the most suitable substance to use in the case of the fulminating mercury manufacture would be the ethereal distillate, which forms a by-product in the manufacture of fulminating silver, as the presence of bone-oil and oil of turpentine gives rise to an undesirable coloration in the manufactured article.—*Chem. Zeit.* **12**, 249.

In a "Note on a Plan for a Nitrogen Iodide Photometer," M. G. Lion proposes, in the *Compt. rend.* **109**, 653–654; 1889, to follow the suggestion of M. Guyard,* and use the property of nitrogen iodide of being decomposed by a ray of light, as means of measuring the photometric powers of different sources. The novelty of his plan consists in using two burettes, each of which contains the reagent, and which are connected together by a capillary tube containing an index of mercury. Each separate beam of light falls on one of the burettes, and any difference in intensity causes a difference in rate of evolution of the nitrogen, which therefore causes a displacement of the mercurial index.

The *Am. Chem. Jour.* **10**, 1888, contains a note by Dr. J. W. Mallet upon the "Influence of Light upon the Explosion of Nitrogen Iodide,"† stating that the instances of explosion of nitrogen iodide, when *under water*, which he has previously described‡ (*Am. Chem. Jour.* **1**, 4–9; 1879), took place when the direct rays of the sun fell upon the explosive, though the explosion was precipitated by friction or concussion. There were but two cases of such explosions, and, as the result of his experience, Mallet finds that under ordinary circumstances nitrogen iodide, while wet, exhibits no extraordinary sensitiveness, and may be safely worked with, only becoming highly dangerous on drying.

C. F. Cross and E. J. Bevan have examined the "Acetyl Derivatives of Cellulose" produced by the method of Franchimont, *Compt. rend.* **92**, 1053, and from the experimental data which they cite, the soluble product of the original reaction appears to be a pentacetyl cellulose. The formation of such a derivative would, of course, have a very important bearing on the constitution of cellulose, and hence the writers reserve any more positive statement regarding the composition of the product until their investigation has been more extended.

Erwig and Koenigs (*Ber. Berl.* 1464 & 2207; 1889), have, however, obtained a pentacetyl dextrose by using this same method.—*Chem. News* **60**, 163; 1889.

C. E. Guignet states, in the *Compt. rend.* **108**, 1258–1259; 1889, that "Colloidal Cellulose" may be produced by immersing in

* Proc. Nav. Inst. **14**, 441; 1888. † Ibid. **14**, 441; 1888. ‡ **13**, 424; 1887.

sulphuric acid of 50° B. filter paper which has been previously treated with HCl and HF, or carded cotton of the finest quality which has been thoroughly dried, care being taken to avoid a rise in temperature while the cellulose is immersed in the acid bath. The cellulose forms a transparent, gelatinous mass, which is not affected by contact with a large excess of acid, but is rapidly converted into dextrine at 100°. When the acid has been completely removed by washing (which is most thoroughly done by finishing with alcohol and drying at the lowest possible temperature), the colloidal cellulose dissolves in pure water, forming a slightly milky solution which is readily filtered, deposits no precipitate even after several hours, and is not affected by boiling. If immersed in sulphuric acid of 60° for a short time, or in acid of 55° for a longer time, it becomes insoluble in water. When treated with nitric acid it forms nitrocellulose in the same way as ordinary cellulose, and becomes slightly less transparent. The author regards parchment paper as a cellular tissue, the pores of which are filled with colloidal cellulose.

English Letters Patent No. 16330, November 28, 1887, have been granted C. Stockes for "Improvement in the Manufacture of Non-inflammable Celluloid Matters," which consist in incorporating a quantity of a metallic salt, such as protochloride of tin dissolved in alcohol, ether, or other suitable solvent, with the celluloid or similar substance made from nitrocellulose.

The appearance of a paper by Mr. V. H. Veley upon one aspect of the subject affords C. F. Cross and E. J. Bevan an opportunity for placing on record some experimental results which have accumulated regarding the "Conditions of Action of Nitric Acid" (*Chem. News* **60**, 13–14; 1889). They have already cited in *Watt's Dict., New Ed.*, Art. Cellulose, their observation that the presence of urea arrests the specific action of nitric acid upon the liquefied cellulose, changing it into one of simple hydrolysis; and they give here the experimental results upon which this observation was founded, together with subsequent ones, which go to show that with the graduated increase of urea there is a gradual departure from the characteristic action of the pure acid, and the results are so very evident to the senses as to make a very striking lecture demonstration.

These results led them to extend the investigation of the influence of urea—*i. e.* of the elimination of nitrous acid—to other actions of nitric acid, taking first metallic copper, when the solvent action of

the nitric acid was almost completely arrested, and these with similar experiments afforded sufficient evidence that the interaction of nitric acid and the metals is another instance of dependence upon the *tertium quid*, which in this case could scarcely be other than nitrous acid.

As the extension of this investigation to the action of mixtures of $HNO_3 + H_2SO_4$ promised to throw further light on the method of formation and constitution of the explosive derivatives of the celluloses and compound celluloses, a series of comparative nitrations of both cotton and jute fiber were made with and without the addition of urea to the acid mixture, and the evidence as to its influence on the reaction was uniformly negative, a result which strengthens the view that the derivatives in question are alcoholic nitrates. When, on the other hand, the formation of a nitro-derivative is involved, the presence of urea may have a very important influence, as shown by Dr. Perkins, Jr., in a recent note on the "Nitration of Anthracene in Presence of Urea" (*Chem. Soc.*), where this modification of conditions proved sufficient to determine a simple substitution in the carbon nucleus.

Frederick J. Smith having to deal with electrolytic gas in a research on explosions in tubes, and believing that some error would be introduced by the use of rubber tubes as usually employed, has devised a flexible tube which seems almost wholly free from the disadvantages of the diffusion of some gases through rubber.

A length of small rubber tube is drawn through another tube of equal length but of greater diameter; each end is furnished with a small length of glass tube fitting the smaller tube; one end is bound off with cord, then the space between the inner and outer tube is filled with water or any liquid required; the other end is then bound off. By this means a "Water-Jacketed Flexible Tube" is easily constructed.—*Chem. News* **60**, 187; 1889.

W. Michelson contributes to the *Ann. Phys. Chem.* **37**, 1–24; 1889, a paper on the "Normal Velocity of Inflammation in Explosive Gaseous Mixtures," in which, after reviewing the work of Davy, Bunsen, Schlösing and Mondésir, Berthelot and Vieille, and of Mallard and Le Chatelier, many of which have been resumed in these Notes, he gives the data obtained from a large number of experiments with mixtures of illuminating gas, hydrogen, carbon monoxide and methane with air, and with oxygen, and the mathe-

matical and graphical discussion of the same. The paper is accompanied by numerous tables, illustrations of apparatus used, and photographs of the flames produced.

M. Neyreneuf contributes to *Ann. Chem. Phys.* **17**, [6], 351–377; 1889, a paper entitled "Researches on the Chemical Harmonica," or singing flame, that contains some fine illustrations of the beautiful figures developed by explosions of gaseous mixtures when burnt in this way.

Berthelot and Petit give in the *Ann. Chim. Phys.* **17** [6], 80–106; 1889, the results of their determinations of the "Heats of Combustion of Carbon in its Different States: Diamond, Graphite and Amorphous," from which we extract the following tabular summary, in which the results obtained by Berthelot and Petit are compared with the famous ones of Favre and Silbermann:

Author.	State of Carbon Ash-free.	Gram-units of Heat per gram.	Kilogram-units of Heat per molugrams.
B. & P.	Amorphous (wood charcoal), .	8137.4 cal.	+ 97.65 Cal.
F. & S.	" " .	8080. "	+ 96.96 "
B. & P.	Graphite, ...	7901.2 "	+ 94.81 "
F. & S.	"	7796. "	+ 93.55 "
		7762. "	+ 93.14 "
B. & P.	Diamond (Cape), ...	7859. "	+ 94.31 "
B. & P.	" (Bort), ...	7860.9 "	+ 94.34 "
F. & S.	"	7770.* "	+ 93.24 "
		7878. "	

In the same volume of the same journal the same authors give on pages 107–140 the results of their determinations of the "Heats of Combustion and Formation of the Nitriles," from which we extract the following tabular summary:

Heats of Combustion.

Name of Compound.	Formula.	State.	Kilogram-units of Heat per molugrams.
Formonitrile, . .	H.CN	liquid.	+ 152.3 Cal.
Acetonitrile, . .	CH_3.CN	"	+ 291.6 "
Propionitrile, . .	C_2H_5.CN	"	+ 446.7 "
Benzonitrile, . .	C_6H_5.CN	"	+ 865.9 "
Benzyl cyanide, .	$C_6H_5.CH_2$.CN	"	+ 1023.8 "
Oxalic nitrile, . .	Cn.CN	gaseous.	+ 262.5 "
Malonic " . .	CH_2.Cn.CN	solid.	+ 395.1 "
Succinic " . .	C_2H_4.Cn.CN	"	+ 546.1 "
Glutaric " . .	C_3H_6.Cn.CN	liquid.	+ 699.8 "

* Number preferred by Favre and Silbermann.

*Heat of Formation from their Elements.**

Name of Compound.	Kilogram-units of Heat per molugrams.
Formonitrile,	+ 23.5 Cal.
Acetonitrile,	+ 0.5 "
Propionitrile,	+ 8.7 "
Benzonitrile,	− 33.1 "
Orthotolunitrile,†	− 34.8 "
Benzyl cyanide,	− 27.9 "
Oxalic nitrile,	− 73.9 "
Malonic nitrile,	− 43.2 "
Succinic nitrile,	− 32.0 "
Glutaric nitrile,	− 22.8 "

The signs and numbers in the above table differ somewhat from those in Berthelot and Petit's final table, but agree with those given under each experiment.

F. Stohmann, C. Kleber, and H. Langbein, *J. pr. Chem.* [2], **40**, 77–95, have determined the "Heat of Combustion" of:

	Heat of Combustion. Calories.	Heat of Formation. Calories.
Durene, $C_{10}H_{14}$,	1393.9	+ 29.1
Pentamethylbenzene, $C_{11}H_{16}$,	1554.1	+ 31.9
Hexamethylbenzene, $C_{12}H_{18}$,	1712.2	+ 36.8
Diphenyl, $C_{12}H_{10}$,	1494.3	− 19.8
Naphthalene, $C_{10}H_8$,	1233.6	− 17.6
Anthracene, $C_{14}H_{10}$,	1694.3	− 33.3
Phenanthrene, $C_{14}H_{10}$,	1693.5	− 32.5

The following conclusions may be drawn from these numbers:

(1). The heat of combustion of the solid homologue of benzene increases, on an average, 155.1 cals. for the addition of each methyl-group.

(2). The substitution of the phenyl-group for hydrogen in benzene, to form diphenyl, increases the heat of combustion by 717.0 cals.

(3). The displacement of a hydrogen atom in the hydrogen molecule by the phenyl-group makes the heat of combustion of the benzene molecule thus formed 718.5 cals. higher than that of the hydrogen molecule.

(4). The formation of diphenyl from benzene, with separation of

* Carbon supposed in state of diamond = + 94.3 cal. † $CH_3.C_6H_4.CN$.

two atoms of hydrogen, takes place without any apparent thermal effect.

(5). The thermal values of anthracene and phenanthrene are practically identical.

(6). The conversion of benzene into naphthalene and naphthalene into anthracene raises the heat of combustion some 458 cals. in each case.—*J. Chem. Soc.* **56**, 1042; 1889.

Berthelot and P. Petit have examined the "Thermo-chemical Relations of the Isomeric Nitro-camphors," *Compt. rend.* **109**, 92–95; 1889, using for this purpose specimens obtained by MM. Heller and Cazeneuve in their study of these bodies. The previous researches of Berthelot have shown that camphor belongs to a special class of aldehydes characterized by the property of combining either with the elements of water to form acids, or with a quantity of oxygen three times as great as for ordinary aldehydes which give rise to bibasic acids with peculiar properties. These derivatives may be represented by diamylenic acid which belongs to the fat acid series, on the one hand, and cymenic acid, which belongs to the aromatic series on the other. The camphenic series thus forms the connecting link by which we pass from the fat acid to the aromatic series. It is quite to be expected then that there should be two nitro-derivatives one of which should be allied to nitro-ethane, and which Berthelot styles *α-camphor nitrate*, and a second which should possess a phenylic function and which he styles *phenol nitro-camphor*.

For the first of these, α-camphor nitrate, which has the formula $C_{10}H_{15}NO_3$, these chemists have found the heat of formation from its elements to be + 89.1 cal., and from camphor (solid) and nitric acid (liquid) + 7.3 cal. This last number is of precisely the same order as the heats of formation of the nitric esters, that of ethyl nitrate being + 6.2 cal. and of nitroglycerine + 4.7 cal. × 3. Hence it is not surprising that these chemists should have found that this camphor nitrate detonated immediately when projected in fine drops into a red-hot tube, and that the superheated vapor detonated also.

The phenol nitro-camphor forms a hydrate of the formula $C_{10}H_{15}NO_3.H_2O$, and this body gave for the heat of formation of the anhydride from its elements + 125.2 cal., and from camphor (solid) and nitric acid (liquid) + 43.4 cal. The last number is very much larger than that for its isomer, and it is related to that of the nitro-derivatives of the aromatic series, which is about 36 to 38 cal. It is

quite to be expected that this nitro-camphor would be less explosive than the former, and the experiments verified this expectation, for when projected in drops into a red-hot tube it was destroyed with carbonization, but without detonation, and the same proved true of the superheated vapor.

In discussing the state of "Unstable Equilibrium of the Atoms," *Zeit. physikal. Chem.* **3**, 145–158, E. Pringsheim says that in substances which readily undergo sudden decomposition or isomeric change the atoms are supposed to be in unstable equilibrium, and he points out that the heat developed in such cases is usually very large, and much greater than the energy required to effect the decomposition; hence, if partial dissociation, in the sense of the Clausius hypothesis, is brought about by sudden raising of the temperature or some other disturbance, the heat generated serves to continue and complete the decomposition.—*Jour. Chem. Soc.* (Abstr.), **672**; 1889.

P. Cazeneuve, *Compt. rend.* **108**, 857–859; 1889, has effected the "Reduction of Nitro-camphor to Nitroso-camphor" by boiling 300 grams of chloronitro-camphor and 1500 grams of 93° alcohol for about one-half hour with a copper-zinc couple made the action of a solution of 100 grams of copper sulphate on 600 grams of granulated zinc. The filtrate was then distilled to dryness, the cupric oxychloride removed by treatment with warm dilute chlorhydric acid, and the residue recrystallized from alcohol, when the nitroso-camphor was obtained as a white, crystalline solid, insoluble in water, slightly soluble in cold alcohol, but more soluble in boiling alcohol or benzene. It alters when exposed to light, becomes greenish, and gives off nitrogen oxides. It is neutral to litmus and orange III, but acid to phenolphthalein. It does not melt before decomposing, but at 180° it suddenly becomes green, entumesces, and evolves nitrogen oxides. If thrown on red-hot platinum it detonates.

A. Behal, in a paper entitled the "Conversion of Methylbenzylidene Chloride into Triphenylbenzene," *Bull. Soc. Chim.* **50**, 635–638, states that the liquid product of the action of phosphorus pentachloride on acetophenone, after standing for eight months, exploded spontaneously, and crystals of triphenylbenzene were formed at the same time. On investigating this phenomenon, the author found

that water determined the decomposition of the original substance into hydrogen chloride, monochlorcinnamene, and acetophone, the latter compound having resulted from the action of water on the previously formed monochlorcinnamene, and that if the latter body were saturated with dry hydrogen chloride and heated in a sealed vessel at 40°, it exploded, with formation of triphenylbenzene crystals.—*J. Chem. Soc.* **56**, 998; 1889.

In the study of the "Pyrimidines" (Metadiazines), *Ber.* **22**, 1612–1635; 1889, A. Perines has obtained the dichlornitroethylpyrimidines, $C_7H_7N_3Cl_2NO_2$, in the form of a yellow powder which explodes when heated.

Among the bodies obtained by D. S. Hector in his study of the "Action of Hydrogen Peroxide on Phenylthiocarbonide," *Ber. Berl.* **22**, 1176–1180; 1889, is the silver nitrate derivative of dianilidoorthodiazothiole, $C_{14}H_{12}N_4S.AgNO_3 + H_2O$, which decomposes on exposure to light and explodes when heated; and the nitroso-derivative, $C_{14}H_{11}N_4S.NO$, which turns yellow when dried and explodes when heated.

Among the derivatives of "Orthonitrosulphanilic Acid" obtained by J. Z. Lerch, *Chem. Centr.* **286**; 1889; *Listy Chem.* **13**, 85–89, is the orthonitroazobenzeneparasulphonic acid, which crystallizes in long yellow pyramids that explode when heated.—*J. Chem. Soc.* 880; 1889.

In describing the "Action of Hydriodic Acid on Allyl Iodide," *Bull. Soc. Chim.* **50**, 449–451, H. Malbot says when hydrogen iodide is passed into allyl iodide some propylene is liberated and great heat is evolved, eventually causing the propylene iodide which has accumulated to decompose with explosion. The explosive substance may be destroyed almost as soon as formed by alternately passing the current of acid and then warming the liquid; an explosion is thus prevented, but at the same time the conversion of propylene iodide into isopropyl iodide is hindered, and nothing is obtained but propylene gas and a residue of iodine, with a little carbonaceous matter. If the allyl iodide is mixed with isopropyl iodide, the reaction is much less violent, but still little if any allyl iodide is converted into isopropyl iodide. If, however, the mixture is cooled with ice and salt, the conversion is nearly complete.—*Jour. Chem. Soc.* **56**, 766; 1889.

K. Buchka states (*Berl. Ber.* **22**, 829–833; 1889) that the "Preparation of Metanitrotoluene" can best be effected by dissolving pure metanitroparatoluidene, prepared by Gattermann's method, in alcohol (3 parts) and concentrated sulphuric acid (3 parts), and adding drop by drop to the cold solution a saturated aqueous solution of sodium nitrite which contains rather more than the calculated quantity of the nitrite. As soon as all of this is added the solution is kept for some time, then carefully warmed until the evolution of nitrogen has ceased and the liquid has assumed a dark brown color. The alcohol is evaporated, the product distilled with steam as long as oil passes over, and the metanitrotoluene extracted with ether. The product thus obtained distills entirely between 228° and 231°, and solidifies when cooled, melting again at 16°. The yield is from 66-84 per cent of the theory, though one experiment gave 90 per cent.

As the result of the "Action of Methyl Diazoacetate on Ethereal Salts of Unsaturated Acids," E. Buchner has obtained the methyl acetylenedicarboxylodiazoacetate, $C_2HN_2(COOMe)_2$, and he has prepared from this ester the acetylenedicarboxylodiazoacetic acid, $C_6H_4N_2O_6$. The silver salt of this acid, he finds, explodes slightly when heated, yielding an oil which is probably either $C_3H_4N_2$ or $C_6H_8N_4$.—*Berl. Ber.* **22**, 842–847; 1889.

"Diamide Hydrate and Other Salts" have been obtained by Curtius and Jay, who have continued their researches upon the compound diamide N_2H_4, which was isolated by the former chemist in 1887. They have obtained the hydrate by distilling diamide hydrochloride with caustic lime in a silver retort, and they find it to be a fuming, corrosive liquid, with a strongly alkaline reaction and a taste like ammonia. It appears to be the strongest reducing agent known, and when dropped on mercuric oxide it explodes violently. The study of the salts shows that when any salt of diamide is mixed with a nitrite, free nitrogen is evolved almost explosively.—*Berl. Ber.* **22**, 134 (*Ref.*); 1889; *J. prk. Chem.* **39**, 27, 107.

From a brief but interesting notice of the life of Dr. J. Peter Griess, *J. Soc. Chem. Ind.* **7**, 612–613; 1888, we learn that he discovered the first one of the diazo-compounds (that curious group of explosive bodies) in 1858. His work on the azo and diazo bodies was continued from that time up nearly to the day of his death, and may be regarded as classic.

In his study of the "Nitroso-compounds of Ruthenium,"* *Compt. rend.* **108**, 854–857; 1889, A. Joly finds that when brown ruthenium sesquichloride is treated with large excess of nitric acid it yields a red nitrate, and when this compound is treated with successive quantities of hydrochloric acid and boiled for a long time, it yields a pale crimson solution of a chloride which, when evaporated at 120°, leaves a brick-red crystalline mass of the composition $RuCl_3NO + H_2O$. When heated at 440° in carbon dioxide or in a vacuum, this salt decomposes rapidly with evolution of oxides of nitrogen, and leaving a residue of ruthenium sesquichloride and dioxide.

Solutions of the nitroso-sesquichloride or of the double alkaline salts are not precipitated by alkalies in the cold, but if the solutions are mixed with sufficient alkaline hydroxide or carbonate to combine with three atoms of chlorine, and are then boiled, a pale brown gelatinous precipitate is formed and the supernatant liquid is neutral. After drying at 150° it forms a black mass with a vitreous lustre, which has the composition $Ru_2O_3(NO)_2 + 2H_2O$. This body is not decomposed by heat at temperatures below 300°, but at 360° it slowly decomposes in a current of carbon dioxide, yielding black graphitoidal oxide, Ru_4O_9, and above 440° it decomposes explosively with incandescence and evolution of oxides of nitrogen.

H. N. Warren, in treating of "Magnesium as a Reagent," states that, as a reagent in the dry way, magnesium reduces all metals with the exception of the alkalies and alkaline earths, and may possibly aid in the decomposition of the latter, provided a suitable combination of the same could be obtained.

An exception to reduction in this line, however, may be mentioned in the powerful manner in which it attracts molybdic anhydride when fused with the same, the combination being so intense as to be accompanied with loud detonations.—*Chem. News* **60**, 187–188; 1889.

In discussing the "Formation of Deposits of Nitrates," A. Müntz and A. Marcano (*Compt. rend.* **108**, 900–902; 1889) have previously attributed the formation of the deposits of nitrates in South America to the enormous deposits of the excrements of birds, bats, etc., which occur in the immense caverns in the Cordilleras (Abstr. 1885, 1042). They now state that the formation of deposits of nitrates can, in fact, actually be watched.

* Proc. Nav. Inst. 15, 92; 1889.

In many large caverns there are no remains of birds, but the soil is charged with nitrates and is found to contain enormous quantities of the bones of mammals. These bones are very friable, and consist of calcium phosphate, with very small quantities of organic matter. Calcium carbonate is absent, and has, indeed, been converted into calcium nitrate, which is found in the earth by which the bones are surrounded. Bone caverns are numerous in Venezuela, not only in the littoral mountains, but also in the flanks of the Cordillera of the Andes. In some cases the deposit exceeds 10 metres in thickness, and the earth is highly charged with the nitric ferment. The quantity of calcium nitrate present varies from 4 to 30 per cent, and the quantity of calcium phosphate from 5 to 60 per cent. These observations confirm their previous conclusions as to the origin of the nitrates.

According to the *Sci. Am.*, July 20, 1889, a family in Haverhill, Mass., were recently seated about an open grate, in the parlor, in which a fire was burning, when an explosion took place which broke a window screen and a pane of glass in a window some feet away and filled the room with smoke, while the report was so loud as to be heard at quite a distance. Examination showed that an ornamental tube, about one inch in diameter, which arched the fire-place was broken, and that the explosion had been caused by the action of the heat upon resin with which the tube had been filled. It is the custom of the trade to fill tubes which are to be bent with resin, so as to prevent them from collapsing during the operation, but it is also the custom to melt the resin and pour it out after the bending is completed. Evidently this had been neglected in this case.

The Boston *Herald*, May 26, 1889, says that those who use the flash lamp in instantaneous photography should be sure and buy the pure magnesium flash powder, as the article commonly known as "flash powder" is a composition containing picric acid, a highly explosive substance. This mixture was harmless before the flash lamp was invented, but in that species of lamp where an air-bulb is used, there is apt to be a suction after the flash which will draw back the flame into the reservoir containing the powder. Several bad accidents have happened to amateurs through neglect to use the pure magnesium powder.

A flash powder which gives a yellow light for use in orthochro-

matic photography is made from one part of metallic magnesium and five to seven parts of sodium nitrate.

The following books are announced:

"L'artillérie actuelle en France et à l'étranger. Canons, fusils, poudres et projectiles." Paris, 1889.

"Hand-book of Gunpowder and Gun-cotton." Wardell, London, 1888.

"Vorschrift über die Versendung von Sprengstoffen und Munitions-gegenständen der Militär- und Marineverwaltung auf Landwegen und auf Schiffen (Sprengstoff-Versendungsvorschrift) nebst militärischen Ausführungsbestimmungen." Berlin, 1889.

"Anleitung zum Zünden von Bohrlochladungen durch Friction u. s. w." Von Johann Lauer. Vienna, 1887.

"Anleitung zur Bestimmung der Bohrloch-Ladungen für Sprengungen in Schlagwetter führenden Gruben." Von Johann Lauer, Vienna, 1887.

"Lauer's Vorschläge zur Verhinderung von Explosionen u. s. w." Von Ed. F. Csánk, Vienna, 1887.

"J. Lauer's Frictionszündmethode." Von J. Mayer. Reprinted from Oester. Zeit. Berg- und Hüttenwesen, 1887.

The *Mittheilungen des Artillerie und Genie-Wesens*, Parts 8 and 9, 1889, contains a Bibliography of the Periodical Military and Technical Literature for the first half of the year 1889, in which we find thirty-two titles of articles on explosives, besides a considerable number on the use of high explosive charges in shells.

"Mining Accidents and their Prevention," by Sir Frederick Abel, with a discussion by some thirty-six experts, to which is appended the laws governing coal-mining in each of the United States and in Great Britain and Germany (431 pp., 1889), is published by the Scientific Publishing Company of New York.

[COPYRIGHTED.]

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

FLEET TACTICS.

By Lieutenant Richard Wainwright, U. S. Navy.

The first question that arises in entering upon the subject is whether or no modern arms and modern inventions have so changed all methods of naval warfare as to make the lessons drawn from history useless, and also if it is impossible to lay down any rules for the guidance of naval commanders besides the few points of minor details that illustrate the handling of a few vessels or single vessels —in fact, minor tactics, with the gun, ram, and torpedo as weapons. If it is true that the march of progress has so altered the conditions of warfare as to make the study of naval history useless, then we have no guide except what can be found in the study of modern naval peace manœuvres and a few recent naval battles, of which that of Lissa is the most important; but even from these slight data it is possible to deduce certain rules, and it will be found that these rules agree with those deduced from historical examples, and that it is only minor tactics which must be radically changed with the improvement of the weapon.

There has always been an outcry raised against laying down rules for the conduct of warfare. Military rules have been opposed because of the numerous elements of uncertainty that enter into every problem, and in the case of naval rules the opposition has been still stronger, because of the additional uncertainty introduced by the necessity of contending with the elements. The great master of the art of war, Jomini himself, says that "war, far from being an exact science, is a terrible and impassioned drama, regulated, it is true, by three or four general principles, but also dependent for its results upon a number of moral and physical complications." In another place he says, "war in its *ensemble* is not a science but an

art. Strategy, particularly, may indeed be regulated by fixed laws resembling those of the positive sciences, but this is not true of war viewed as a whole. Among other things, combats may be mentioned as often being quite independent of scientific combinations, and they may become essentially dramatic, personal qualities and inspirations and a thousand other things frequently being the controlling elements. Shall I be understood as saying that there are no such things as tactical rules, and that no theory of tactics can be useful? What military man of intelligence would be guilty of such an absurdity?" Baron de Jomini lays down general rules for the guidance of the military student, and, by analyzing numerous campaigns and battles, shows how he has derived the rules and illustrates the battles. The march of improvement on land has been great, and yet Jomini is still an authority of the highest value. Because the improvement in the weapons at sea has been great, and because all rules are difficult of application to warfare on the sea, the elements of uncertainty being numerous, shall we therefore say that naval warfare not only is not a science, but also is not even an art? that it is a mere matter of brute force? that no rules can be used as a guide, and that the naval commander must trust to the hard fighting of his individual vessels, and that the best work an admiral can do for his fleet is to command the largest vessel and make it conspicuous in the fight? One might answer in the language of Jomini, What naval (military) man would be guilty of this absurdity? were it not for the high naval authority cast upon the side of no rules—not openly and plainly, yet with language that will bear no other construction.

Many officers beyond doubt think that there is no better method to conduct a fleet than to carry it on the shortest road to the enemy, trusting to hard fighting to win the day. They say that on the sea all operations and manœuvres are plainly visible to the enemy, whereas on land there may be doubts in the mind of either side as to the position and strength of the troops opposed, and a portion of the line may be strengthened or weakened without the knowledge of the opposing force. Strategy, with its political, geographical, and military or regular strategic points, remains now, as throughout the history of war, the same, but tactics are useless. The advocates of brute force are not confined to those who pin their faith on any one weapon; there are adherents of the gun, the ram, and the torpedo, who point to the sentence extracted from Nelson's famous Trafalgar order, "No captain can do wrong if he places his ship alongside that

of an enemy," as the best rule of the greatest of naval commanders, and yet every line of that order, of which the above is a short extract, shows Nelson to be a believer in tactics and a great tactician, and throughout it he is striving to line out the course to be pursued by his fleet, in accordance with the various positions of the enemy, so that he may combine his strength upon a portion of the enemy's, the aim of all tacticians. The tactics to be pursued in any given case must somewhat depend upon strategical considerations. It may frequently happen that it is not to the best interests of the country to risk a decisive battle, for the resources of the enemy may be so superior that the loss incurred in defeating him will be ruinous to us while not felt seriously by him. If our enemy be decidedly inferior to us, it may be wise to endeavor to overwhelm him at all points at once; but where the two fleets are nearly equal, we can hardly expect that our fighting qualities will be so far superior to his as to give us a decided victory. If both sides rush together and engage in a *mêlée*, chance will rule; but the result must be disastrous to both fleets, and the victor of such a combat can have but little fighting value left. In most of the great battles won by the English fleets they gained some decided tactical advantage in the outset through superior handling of their fleets, and in those days their superior seamanship and gunnery, and higher state of discipline made an English vessel far superior to a French, Spanish, or Dutch vessel of the same size. We know that many of their commanders, notably Collingwood, paid great attention to rapidity of fire. The fire was generally reserved until close quarters, and then poured in by broadsides; the opposing crews, less skillful and fatigued by firing at long range, could not compete with the English in rapidity of fire, and their guns were silenced. The slaughter was usually far greater on the enemy's vessels than on the English, and, although courageously fought, they were obliged to surrender. This great slaughter was largely due, undoubtedly, to the rapid firing, and some may have been due to superior ballistics. Because of this superiority, they adopted the tactics, when to windward, of cutting through the enemy's line and engaging him to leeward, thus preventing him from slipping away to leeward when disabled. Can we expect to have this superiority to all enemies?

In 1812 our officers and vessels were superior to the English, and our crews at least their equals, but the fact remains that in spite of our victories in the naval duels, if the war had continued longer, we

would have been without a vessel able to keep the sea. It would be egregious vanity for us to assume any individual superiority over European vessels or fleets as now situated, and if our only dependence must be on hard fighting,—unless we contemplate building a naval force equal or superior to our possible foes,—we might as well cease our endeavors to build up a navy. It certainly seems improbable that for many years to come we can expect to have a large fleet. We may hope to have a small fleet of battle-ships, and if this must rush at the enemy whenever he is sighted, we may expect to beat him once, we may hope to defeat his second fleet, but for a third encounter we would certainly have no fleet. There may arise occasions when, because of the political situation, it may be necessary to risk our small fleet; that is, an immediate victory may serve to prevent another nation from joining the enemy, or may serve to induce an ally to join us, but certainly under ordinary occasions it would be foolhardy to attack the enemy at once and insure our final destruction, while on these extraordinary occasions it certainly would be wise to endeavor by manœuvres to gain some advantage over the enemy, and, while destroying him, preserve as many of our vessels as possible.

To begin with, let us see if we cannot find some rules by which we may be guided, and from which, if we follow them, we may hope for advantage, and which, if we violate them, will plainly give the enemy the advantage if he adopts the correct course.

There will be three cases to consider in the conduct of a fleet; when meeting one of equal strength, when meeting one of superior strength, and when meeting one of inferior strength.

When meeting an equal force, the first thing to be considered is whether an immediate and decisive action is necessary to the interests of the country, or whether it is advisable merely to delay the enemy until we can receive reinforcements; or, is our fleet so important to us that it must not be risked until we have reasonable certainty of a complete victory? Undoubtedly the most satisfactory course for any commander to pursue is to press on to an immediate engagement; his responsibilities are lighter, and his anxiety is shortened. He has only to have confidence in his own courage and that of his officers. Even if he should be defeated he can fight hard, injure his enemy, and leave his courage unimpugned. On the other hand, if he wait, he must be vigilant day and night; he must restrain those who, desirous of ending their anxiety, will try to force a fight. He knows that if by an unfortunate accident he should lose touch of the

enemy he will be subjected to adverse criticism. There will always be those under him whose only idea of fighting is to have it out at once, win or lose, and until he has achieved success they will believe he is wanting in courage. The adventurous side will always be popular. Still, the commander of a fleet of the United States will in many cases find it his duty to risk little in order to preserve his fleet in fighting condition, and win the game by strategy and tactics in place of hard fighting. Suppose we had but a fleet of eight battle-ships—and it must be some time to come before we shall have that force: the enemy, say England, having many vessels, sends a fleet of eight battle-ships to attack our coast. If we were to attack that fleet, rush out and meet it half way, we might be victorious; in fact, I think we would be victorious, but at the end of the battle I should expect to find our fleet utterly unfit for further contests. The next fleet that came over would have free play on our coast as far as any opposition from our fleet was concerned. Now, history shows us how a small fleet may be handled to advantage in the defense of a coast where the principal points are fortified; and I think common-sense reasons may be shown by which a waiting game may be made to pay, and how a flanking fleet may be a powerful defensive weapon in the hands of an able commander.

The first and easiest case to handle is where the two opposing fleets are equal and both desire to bring on an engagement. Still the question is sufficiently complicated. What shall be the order of battle, and will the fleets stand off and use the guns, or will they close for a ramming encounter? Again, we have those officers who care little about the formation but who would attempt to ram their enemy at all hazards, and there are some good arguments on their side. They have only to concentrate their mind on one idea; straight for the enemy is all they need think about. Their mind is made up, and immediately the enemy is sighted there is no hesitation on their part. If the enemy hesitate or flinch, they will undoubtedly be caught at a disadvantage and probably rammed and defeated. This would undoubtedly be the better course to pursue if you were certain of the pluck of your officers, but doubtful of their skill and your judgment. We certainly can always depend upon the pluck of our officers, and by proper training we should be able to depend upon their skill.

Now for the method of attack. Jomini says that no rational man would, under ordinary circumstances, attempt to attack along the whole extent of an enemy's line; that there are always three points

for him to choose from, the right, center, or left, two of which may be equally good and the third can be rejected. On land it is usual to endeavor to extend the front equal to that covered by the enemy, to prevent outflanking, because troops struck in the flank are crushed in detail and rolled up unless strongly supported; but the movement of vessels is more rapid and free, and there is not the same danger from having the flank overlapped by the enemy. Upon sighting the enemy the commander would ordinarily be able to determine immediately the point upon which he intended to press his attack. Before indicating the circumstances that will guide him, it will be first necessary to open the vexed question of the relative importance of the modern weapons, the gun, the ram, and the torpedo. It is here necessary to state I am a firm believer in the gun as the first and foremost weapon. And it seems to me that it is the only position to be maintained logically. I believe that within certain limits you can say what the gun will do, what the ram may do, and what you hope the torpedo will do. And in starting from the other end you can draw the limits of the power of the weapons very closely. For the torpedo the degree of accuracy is poor, the range is short, the number of shots few, and the damage is not greatly in excess of shell. With the ram, while the range is still shorter and the probable damage is greater, the delivery of the blows must be few and far between. The number of blows from the gun are practically unlimited; for the smaller calibers the rapidity with which they can be delivered is very great, and the destructive effect of the larger calibers almost as great as that of the other weapons. I believe each has an appropriate time for its use and its distinct tactical value; besides this, there is a strategic value that may overbalance the tactical one. It must be remembered that the subject of fleet actions is now being discussed, as in individual duels there is room for a different discussion of these weapons. In the case of the gun, the commander of a fleet who has had an opportunity properly to exercise his fleet, and who finds it manned with well trained gunners, should be able to calculate very closely the damage he may reasonably expect to inflict with his guns, according to the composition of the enemy's fleet and the state of sea and weather. He should be able to select a range and concentration of fire that would insure his damaging the enemy. In this selection, and in so handling his fleet, his personal skill would be clearly manifested. With highly trained gunners, good guns, and well protected ships, he

would leave less to chance by using the gun than if he selected the ram. If he should select the ram, he can make the best arrangement to rush to the attack, but after that, he can have but little management of his fleet, and his success or failure must largely depend upon individual skill and the accidents of a close encounter, and it would be out of his power to remedy any defects in the execution of his programme after it was once initiated. Certainly a commander who is confident of his own skill and of his power to wield his fleet as a single machine, would prefer that weapon upon which he can base his calculations and throw out the element of chance as far as possible. He would first use the gun until, his calculations proving correct, he had disabled a portion of his enemy's fleet; then the great value of the ram would be seen; it certainly becomes a highly powerful weapon when wielded against a disabled antagonist. At this time its value far exceeds that of the gun, and a good commander would push his advantage home with the ram. Much has been claimed for the torpedo, but whenever it has been practically tested its performance has fallen far below the expectations of its advocates. As at present developed, it has little or no tactical value in fleet actions. Not that I would advocate doing away with the torpedo in battle-ships; only I would be willing to sacrifice very little to the weapon, and it would not alter in the slightest degree the tactical disposition of the fleet or the manœuvres in battle. It may help to disable an enemy, and in the case of a vessel already disabled it may enable her to injure the vessel that is about to ram; but it is hardly powerful enough to prevent ramming, and is too uncertain in its action and effect to change the manœuvres of the vessels engaged. Many will say that in selecting a range at which to engage, concentrating the fire and finally charging the disabled vessels with the ram, the enemy can take the same advantages; this is true of all strategy and all tactics, and at sea, where all motions are plainly visible to the enemy, he would be aware of each manœuvre and could make the proper reply. The only thing is to be prepared and make the best moves according to sound tactics, and if the best reply was made, the terms would still be equal; but if a weak move should be made, and a strong reply by the enemy, the latter would then have an advantage. In studying the tactics of all naval battles, the moves made by the successful commander are readily comprehended, and the reply is plain to the student; he wonders why the defeated commander failed to make it, until he realizes that what

is so plain on paper becomes more difficult when undertaken amid the excitement and confusion of a battle when resting under the responsibility of conducting a fleet. He realizes that the commander who despises tactics and considers it too simple a matter to be worthy of study, meets his antagonist without preparation, and for want of a proper reply is defeated, while the successful commander, having the few simple rules well in mind, and having considered their application to all the possible positions of the enemy, is ready to make the strong move and take every advantage of his enemy, and defeats him. The old method of doubling up on the enemy's line was always easily answered by starting to double back on his line when he made the move, but this reply was generally neglected. And in all history there is very rarely seen a case at sea or on land where more than two or three strong moves are followed by the same number of sound replying moves; although plain and simple to the student, to the commander in action they become difficult, and sooner or later the more skillful gains a decided advantage. Perhaps the finest campaign in all history to study and see the best move followed by the strongest reply is the advance of Sherman upon Atlanta, and Johnson's retreat upon that city. Johnson had the weaker force and must retreat if properly pushed, and yet he was too strong to be attacked rashly. Sherman would extend one flank or the other, and by threatening Johnson's flank, or threatening to cut him off from his base, would force the Southern army to retreat. Johnson would retreat at the right moment and fall back to the next strategic point with great skill. Had Johnson made a mistake, he must have suffered a crushing defeat; had Sherman made a false move, if not defeated, his advance would have been checked and he must have awaited the arrival of reinforcements.

The range at which it is best to engage now becomes a question for consideration, and this can be readily fixed for our present guns by reference to the "Text-Book of Ordnance and Gunnery," by Lieutenants Meigs and Ingersoll, and the "Tactics of the Gun," by Lieutenant Meigs. With our present guns and with the present type of battle-ship, 2000 yards should be the opening range under ordinary circumstances, as then the probable target would catch one fourth of the shots fired. The effective range being about 1100 yards, the inside range, or where the gun is no longer supreme, is affected by three things: the range of the torpedo, from 300 to 400 yards; the magazine rifles and machine guns, their fire becoming

dangerous at less than 500 yards; and the danger of being rammed, which depends upon the tactical diameter of vessels engaged. This latter is the most important limitation to the range to be selected, for if within the space where the enemy may ram, it becomes necessary to turn your bows to his vessels, unless you have superior speed and intend to run away. Leaving this out of the question, if you come within this distance, a ramming conflict becomes inevitable, and the gun is subordinated to other weapons. Therefore the range will ordinarily be in the neighborhood of 1000 yards, not over 2000 and not under 600 yards. Should the enemy's vessels be slightly protected in comparison to ours, or should his guns be of less power, it may be advisable to engage at greater ranges so as to take full advantage of our superiority. The angle of presentment is the next point to be considered, and this is regulated by the distribution of the guns and armor. The modern tendency is to armor the entire exposed surface and give strong bow fire; then, approaching end on, or nearly end on, will allow the use of full strength of fire and expose the least surface with the armor at the best angle; but when intending to carry on a gunnery combat there will be very little time occupied in passing from the outer to the inner limit of the gunnery range, so that the angle of presentment must be regulated so as to keep the fleet between the limits and yet as much less than 90° as possible.

The next question is the order of formation. The fleet should be so formed as to give full opportunity for engaging with the battery, and yet it must be a flexible formation, readily maintained and easily reformed when once broken. The first thing to be observed by a fleet is close order, and this should be very close, so as to give good mutual support in case of ramming. Then if your vessels are nearer together than the enemy's, you have a greater force than his on some part of the line, and you move your vessels in less space. A formation in column is generally bad, for many reasons, and certainly in very close order it becomes dangerous if steaming at high speeds. Should one vessel become disabled, the line might be thrown into disorder and collisions might take place. A formation in line is bad, as it does not permit a full development of the fire of the battery, and should the enemy pass through, your shot would be almost as dangerous to friend as to foe, and any vessel disabled and dropping astern would be without protection. I believe that a bow and quarter line, or *échelon*, is the formation that most nearly answers

the requirements, and this in spite of the adverse criticisms in "Modern Naval Tactics." Admiral Randolph makes the following remarks on bow and quarter line: "It is hard to preserve; the opportunities, however, for using the battery are very good. It is not the most efficient for mutual protection from ramming, as the sternmost of two vessels receives none from her bow neighbor, and the leader of two, not the utmost possible from her quarter neighbor. Furthermore, it is not a good formation for ordinary steaming, as it is hard to maintain your station, and is difficult to change direction in, although it permits great liberty of movement of the vessels themselves."*

In three years' experience in the North Atlantic Squadron I have seen the vessels frequently cruising together in most of the prescribed formations, and do not believe that it is hard to preserve this formation or difficult for vessels to maintain their stations. Commander Colby M. Chester used on the Galena, attached to the squadron, a small instrument that greatly facilitated keeping in position in any formation except column of vessels. It consisted of an alidade on deck with a rigid connection to the engine room below, where a pointer was attached that moved with the alidade. When in position, the pointer was set at the zero of the scale with the alidade on the mainmast of the guide. A man was stationed to keep the alidade on the mainmast of the guide, so that the position of the pointer showed the engineer on watch how the ship was maintaining her bearing with the guide, and when it was necessary to diminish or increase the number of revolutions of the propeller. All that is necessary beyond this is for each vessel to have the error of the compass accurately known and to steer a fairly straight course. To change the direction of the line of bearing, bring the fleet into column of vessels in natural or reverse order by a simultaneous change of course to the direction of the line of bearing $\frac{1}{8}$ or $\frac{3}{8}$ of a circle. Then give the leading vessel, the guide, the direction of the new line of bearing as a course; this will be taken by each vessel in succession. When all are on this line, give the new course, making an angle of 45 degrees with the new line of bearing; this will be assumed by the vessels simultaneously and they will be in bow and quarter line. The direction can be changed by wheeling while in this formation as readily as when in line abreast, but wheeling with an extended front of vessels is an awkward manœuvre. Even if the bow and quarter

* "Modern Naval Tactics," Commander Bainbridge-Hoff, U. S. N.

line is a difficult formation to maintain, we must increase our skill in holding positions. As we cannot afford to reject fine instruments of precision because sailors have been accustomed for a long time to the handling of coarse ones, so we cannot afford to reject formations or evolutions because we lack experience. The officers and men must be educated up to the required point. With every improvement introduced in the Navy have come objections from some that the instrument was too intricate to be placed in the hands of sailors; still, so far, neither the sailor nor the officer has failed when called upon for additional skill, knowledge, or intelligence; all that is needed is time to adapt themselves to the instrument or method that they are required to use. Commander Bainbridge-Hoff says: "Formations *en échelon* present to the enemy a line of rams and a line of fire. Yet it is a dangerously bad formation if it is attacked in its line of bearing, as it is not flexible." I think he has gained the impression of the want of flexibility in the formation from the old method of handling a fleet *en échelon*, viz., forming it only from line abreast and requiring a return to line abreast to change the formation; this is all changed in the new evolutions with which he has had so much to do, and certainly there is no want of flexibility if properly handled. As to its weakness, in all formations there are points of weakness and points of strength against an attack. In line abreast, which is strongly advocated by some, an attack upon either flank would find the weak point of the formation. To meet this by a change of direction, there being sufficient time to make the change, would take no longer *en échelon* than in line abreast. And to meet it by change to column would require the vessels *en échelon* to alter their course forty-five degrees against ninety degrees for those vessels in line abreast. The fact that this formation presents to the enemy both rams and a line of fire, and permits great liberty of movement to the vessels themselves, more than balances any disadvantages there may be in this formation. The introduction of the ram and torpedo caused many to remodel their ideas of naval tactics, and a rather sudden departure was made from old formations and manœuvres. It may be that this was too sudden, and that where so much must be speculation and derived from paper arguments, we may still be able to take some lessons from history. Sir Howard Douglas carefully derives his steam tactics from experience with sailing vessels and from the history of naval warfare when sail was the motive power. All this was thrown aside when the ram was re-introduced, but more modern

experience has shown, I think, that his arguments were well founded and need only slight changes to adapt them to the present time. Thus it is no longer necessary to bring the broadside to bear upon the enemy in order to deliver the full strength of the battery. By consulting the valuable diagrams of Lieutenant Chambers in General Information Series Nos. 5 and 6, it will be seen that the average vessel can deliver as effective a fire at an angle of fifty degrees from the keel as at ninety. Because of the ram, it is advisable to meet the enemy nearly head on, and it may be advisable to alter the angle of the keel with the line of bearing from forty-five to something nearer ninety, and this may be done without sacrificing any strength of fire. The group system has been strongly advocated, and many ingenious evolutions have been laid down, but the system is cumbersome and sacrifices a portion of the offensive strength of the fleet to increase the power of defense; its advocates have been misled by the undue prominence given the ram. In groups of three, a portion of the fire strength is sacrificed, and there will be a strong tendency to split into groups after the first rush of the attack. There are times when the group system may be advisable; such as when our fleet is somewhat weaker than that of the enemy and it is necessary to make a strong showing and to run unusual risks in our attempt to defeat the enemy; then the unarmored vessels may be brought into the line of battle, and their inherent weakness somewhat remedied by the formation of groups, preferably groups of twos.

The ideal fleet is one composed of eight line-of-battle ships in four divisions of two each, right, center, left, and reserve divisions. This forms groups of two, but very pliable groups; the divisions keeping together in fleet formation as long as possible and then separating into pairs; each division to have its fast cruiser and sea-going torpedo-boat, and the fleet to have in addition such specially devised boats, rams, and dynamite cruisers as may be deemed advisable; six vessels to cruise together in *en échelon*, cruisers sent out as scouts, and the reserve with torpedo-boats, etc., in the rear.

There is good authority for placing unarmored vessels in the line of battle. Still, believing as I do that the gun is the principal weapon, and that it would be allowable to place them in the line only in some such exceptional cases as mentioned above, the argument of Admiral Sir Geoffrey Hornby, K. C. B., seems unanswerable. The Admiral says: "You may put an ironclad in any position you please, and if she is attacked by three of these unarmored vessels she will

make a run at one vessel or the other, attack her with her guns, and threaten her with her ram, and it must be death to that vessel if she touches her in any way. The two other vessels, you say, will follow and disturb the action of the ironclad; but it must be recollected that the ironclad will always be firing at them, one gun at least, and with shells, the bursting power of which must necessarily, as far as we know, destroy the fighting power of the cruiser. If any one contemplates what the bursting of a shell filled with 37 pounds of powder in the center of any unarmored vessel would be, I think he would agree there would be no more fight left in the ship. It is no answer to say that the ship is armed with a gun as heavy as the ironclad has; the *morale* of the people will be destroyed, and they will be unable to continue the action against the concentrated force to which they are opposed. For that reason I hold that the unarmored ship cannot contend against the armored."*

The improvement in rapid-fire guns, and the adaptation of the system to larger calibers makes it a necessity to protect the people working the batteries against shell from these guns. Therefore the unarmored vessels will cruise in advance and on the flanks, acting as scouts and giving warning of the approach of the enemy, and then taking up positions well away on the flanks. The fleet will be so manœuvred as to bring the line of bearing in such a direction as to make an angle of 45° with the enemy's course, and the course of the vessels so varied as to draw the line towards the enemy and also to give full development to the fire. If he is in line and shows signs of intending to charge through, fix the course so as to bring the bows of the vessels to the bows of the enemy. The fleet will then be *en échelon*.

With the fleet right in front, under ordinary circumstances, the reserve division will support the left flank, as it is most in danger of being doubled on; and should it be evident that the enemy have no intention of adopting ramming tactics, they can be used to lengthen the firing line. In all cases such torpedo-boats and rams as may be attached to the fleet will shelter themselves behind the battle-ships until the confusion of the enemy or the smoke affords good cover for an attack. When the left is clear of the enemy, all go about with the same helm as pre-arranged or signaled, and stand down for the enemy again. If the enemy decide to pass our line firing, the fleet will be so handled as to keep about one thousand yards from the enemy's vessels, and

* "Modern Naval Tactics," Commander Bainbridge-Hoff.

at the same time to give ample opportunity to the batteries, the effort being made to draw the fleet past one flank of the enemy without incurring the dangers of an oblique attack. In the days of sailing vessels and smooth-bore guns the oblique attack nearly always proved ruinous to the attacking party, for his leading vessels were exposed to the fire of the entire line of the enemy, and were badly cut up before the guns of the rear vessels could be brought to bear. At the present time there is less danger, as the vessels are a much shorter time under fire, owing to their great speed, and nearly the whole strength of fire can be brought to bear as the guns are now distributed. Still, an oblique attack tends to induce the enemy to concentrate his fire upon the leading vessels. The fire of the heavy guns of the fleet will be concentrated upon one or two vessels of the enemy, according to the distance, state of sea, and weight of fire of the fleet, taking into account the probable number of hits and the disposition of the armor of the opposing vessels, the idea being to insure as nearly as possible the disabling of at least one of the enemy's vessels, rather than distributing the damage over several vessels. Should some of the enemy be more lightly armored than others, they should be selected as the target, if so placed in the line as to be readily aimed at. One vessel disabled will tend more to throw the enemy's line into confusion than if the hits were distributed; besides, with distributed hits the damage may be repaired without reducing the fighting efficiency of the vessel. The fire of the lighter calibers, particularly the quick-firing guns, should be left to the commander of each vessel, he pouring it into his nearest available enemy, so as to keep down the fire of the heavy guns, damage torpedo tubes, and riddle unarmored ends.

If the enemy decides to try ramming tactics and attacks formed in column, he will charge through some portion of the line; the reserve and torpedoes will form in rear and strengthen that portion. The concentrated fire of the fleet should be able to damage the leading vessels of the column. The reserve must be ready to fill any gap in the line that may be caused by vessels being disabled, the most likely point being where the enemy charges through the line, for the vessels there will be liable to be rammed, and will receive the fire of the enemy as they pass through. The torpedo-boats will be ready to attack any disabled vessel of the enemy, and with the reserve must make a strong attack on the rear vessels, should the others succeed in getting through without being disabled. If the enemy attempts

to ram with his vessels in line, the ordinary position for the reserve would be in rear of the center division.

The question of weather or lee gage has given rise to some controversy. If it were possible to hold the weather gage during an action without sacrificing other points, it would be well to hold it; for to windward you can see your own ships and gain occasional glimpses of the enemy, while to leeward you can see but little of either. But with steam fleets in action, the interchange of positions is likely to be rapid and frequent; it would then be preferable to start from the leeward position, as then, the formation being well preserved, the position of your own vessels and that of the enemy would be known, and after charging through you would have the weather position clear of the smoke in which to reform the fleet, and the enemy would have the drifting smoke to add to his confusion. At least this is the conclusion I have reached after witnessing many target practices and some sham attacks where blank charges were used. "Parker's Steam Tactics" is the only authority I can quote to support my idea as to the position of the admiral in command of a fleet in action. All former experience seems to be against me, and yet I find myself unable to relinquish the opinion that the line of battle is as improper a position for the commander of a modern fleet as it is for the general of an army. The history of former naval battles shows us that the admiral arranged his plans before the action, informed his captains, and after hoisting the signal for going into action, closed his signal-book and turned his attention to fighting his flagship until the close of the action, when he resumed his office of admiral. The following appears to be the idea most generally held: "The admiral's flag belongs on the largest and most powerful vessel, which should outshine all others as a brilliant example in the heat of battle. History shows that the admiral must himself be in the midst of the fight. If he wishes to be the vital element in his ship and to make the best use of all the components of his command, then he must put himself in a position to see everything and to be seen of all."*

How an admiral can see everything and make the best use of all the components of his command, and at the same time outshine all others as a brilliant example in the heat of battle, is hard to conceive. It sounds well, but it is not practicable. There is now greater opportunity for the tactician to handle a modern fleet, and an admiral can

* "Modern Naval Tactics," Commander Bainbridge-Hoff.

be better employed than he would be if setting an example by the way he fights his flagship. When we have to fight modern vessels we shall have no lack of captains to fight them boldly, bravely, and skillfully; but if the combat is to be with the fleet combined, and not a confused *mêlée* of separate conflicts between two or three vessels, the fleet will require the undivided attention of the admiral, and he should be so placed as to be able to concentrate himself upon the entire action, and not have his attention especially drawn to the conduct of one vessel. Being in the most powerful ship, he would be most likely to disable an enemy, and in the charge through might be detained to give the *coup de grâce*, while his fleet, having passed through, would be without his direction when reforming. Again, to him is confided the policy of his government and the condition of the entire force at its disposal, and he will have carefully estimated what risks it is wise to run with his fleet; and the exigencies of the case may require him to withdraw his fleet from action, which would be a difficult task if he were in the thick of the fight, even if he were able from this position to judge of the condition of affairs. I firmly believe that the admiral should withdraw as much as practicable from the heat of the battle by taking his station on a strongly protected despatch-boat, in designing which everything must be sacrificed to speed and buoyancy. During the artillery portion of the combat he can shelter his vessel under the battle-ships, and in the charge through escape at the flanks. He may run as little risk as is consistent with keeping his fleet well in sight, unless in cases of desperate emergency, when, as a general may sometimes choose to lead a last charge, he may go on board one of his vessels of the line and lead the attack upon the enemy. Undoubtedly, it will require some moral courage for an admiral to take his station in battle on a despatch-boat, at least until the idea receives more general approval. He will think of the long line of illustrious men who have always been in the thickest of the fight. Some will point to the time at Mobile when Farragut, rushing ahead with his flagship, saved the fleet and won the battle; but, on the other hand, if Admiral Byng's attention had not been distracted by a collision, he might have signaled to his rear squadron to engage, and perhaps have gained a victory off Minorca; at least he would have saved his reputation and his life. Still, if the admiral has had practice with his fleet, and finds his captains skillful in manœuvring, and the fleet under his control acting as a machine, he will not only take pride in handling it, but will have

confidence that in its combined action lies the secret of success. And he will feel that his station on a despatch-vessel, while it does not withdraw him from danger, gives him a position from which he can see and manœuvre his fleet, so that it becomes a mighty engine of destruction in his hands, and not a mere conglomeration of vessels. He will prearrange his plans as far as possible, and fully inform the captains of his intentions and desires. Many points may admit of preconcerted action, particularly which helm is to be used in turning after the charge through; but, for the skillful manœuvring of the fleet, signals will be wanted, and we need further practice with battle signals. Flag signals must be frequently obscured during an action, and some other method of communicating with the fleet must be adopted. I think the so-called Japanese day signals would be found to work admirably. These signals are light wooden bombs, projected into the air from mortars. When they explode they throw out shapes, which can be greatly varied and are readily distinguished at a considerable distance. The smoke lies most thickly near the water, and these signals, thrown well up into the air, would be usually visible from deck, and always from an elevated point aloft. The numbers and combinations necessary for battle signals would be few. Large distinguishing flags or shapes should be carried at the highest points by all the vessels of the fleet, so that the admiral may readily judge of their positions. These would be generally visible from aloft.

An attack having been decided upon, and the force of the enemy being equal to ours, what point of his line shall we attack? There are many different situations which may arise that will require each a different answer. If the enemy should be formed in column, particularly if he shows signs of intending to ram, the head of the column would seem the best point upon which to concentrate the fire of the vessels, for, by disabling the leader or leaders, the column would be thrown into disorder. As in all cases when it has been decided to bring the enemy to close quarters, if he is determined to charge through and try the ram, we must present our bows, and cannot prevent his using the ram, so in this case we must endeavor so to set the course of our fleet as to cause him to charge through at or near our center. This will give our vessels all along the line the best opportunity to fire at the leading vessels of his column, and should he be able to pierce our line near either flank he might be able to detach and destroy the flanking vessels. He should never be allowed when in

column to pass along either flank of our fleet, for then he would have the advantage of concentration upon the flank vessel. If he attempt this by withdrawing or refusing the squadron on that flank until his center has passed, we can head for his line and charge through. But the best point for us to make would be to oppose our center to his leading vessels, when we could combine the fire of six of our vessels on his one or two during the advance, the two in the reserve division being ready to meet with their fire the vessels as they pass through. Here the enemy would be able to pour the fire of their eight vessels into our center vessels; still, at this point, each vessel of the enemy will meet with the fire of four of ours, the two between which they are passing and the two of the reserve squadron.

It is true that the enemy having reserved their fire from necessity, being in column, will be able to use their heavy calibers, but at this range the smaller calibers, the quick-firing and machine guns and magazine rifles will have the advantage; the smoke will be great and the heavy guns must be fired unaimed and amid a shower of missiles from our four vessels. I think the chances will favor our damaging his leading vessel and escaping with our center vessels uninjured. If the leading vessel is injured, some of our torpedo-boats or rams should finish its career. The enemy may charge through our fleet without ramming; it would seem as if it would be natural for our vessels to crowd imperceptibly a little towards the flanks, leaving him a free passage, and it would certainly seem a most dangerous attempt for any of his vessels to sheer out of the column and attempt to ram; if he should charge through, our two center vessels and reserve squadron, with torpedo-boats and rams, if we have any, should block the way for the rear of the column and attempt their destruction. But should the shock come, and his leaders meet our vessels with the ram, their speed must be suddenly checked; the other vessels must sheer to continue their course, his formation must be broken, he must meet our rams at a disadvantage, and we should succeed in doing far the greatest injury. I firmly believe that the attempt to charge in column or columns will always prove fatal to the fleet making the attempt; that their complete success at the point of shock by ramming their opponents would be their own undoing, as in arresting the advance of the leaders the mass would be thrown into confusion, and would in turn become the prey of a well-formed line. The impetus of the body is not increased by its mass; it must fly apart at the first shock unless it would be its own

instrument of destruction; it cannot submit to further compression with safety. Then the leaders should be damaged by our concentrated fire and would have therefore less than an even chance at the point of shock.

If the enemy be formed in line and he decide to ram, our line should be so manœuvred as to bring our center opposite to one of his flanks—to his right flank if our bow and quarter line is formed right in front, and to his left flank if our fleet is left in front. This would enable the fire of our fleet to be concentrated on his flank vessels, and if he in turn concentrate on our flank vessels they will be farther away, being refused, than if we attacked on the other flank. The reserve will strengthen the flank that must charge through the enemy. Such of the fleet as clear the enemy's flank should change direction simultaneously 12 points towards the enemy—that is, to the left if right in front, to the right if left in front—and follow up his engaged wing. If this wing has continued its course, our vessels will again change course simultaneously 4 points, when in their rear, and follow them up. If the enemy attempt to turn immediately after passing through our line, our fresh wing would strike them in the flank when they were disordered and when they were probably weakened by the attack of the first wing. The first wing should go about together as soon as the last vessel was clear of the enemy's line, and be ready with the reserve to meet the enemy's fresh wing. The torpedo-boats and rams will keep in rear of the wing that clears the enemy, and change course and move down upon the enemy with that wing.

If the enemy intend to engage in an artillery conflict he will be in some extended formation, as line or *échelon*. Then selecting the same flank as before, that is, his left, if we are right in front and *vice versa*, we try to draw our line along this flank; if he make the correct reply to this move the fleets will pass on parallel lines and all will depend upon accuracy and concentration of fire. Then on most occasions the fleet would go about, change direction 16 points, and pass again, watching for the opportunity to strike with the ram when vessels were disabled or the fleet disorganized. In all cases the gun would be our first and principal weapon, and whether he charged our line or passed firing we should attempt by concentrating the fire of our vessels to injure seriously one or more of his. If forced to ram by him, our concentration of fire should give us the advantage before the shock; if not forced, we should gain a decided advantage before

using the ram. Never waste our ammunition at great ranges and pour in the lighter missiles at close quarters.

The formations and evolutions necessary for such tactics are very simple; column, line, and *échelon* are the only formations necessary, and the change from one to the other by simultaneous or successive changes of course. But the formation in column should never be a complete bow and stern line; each vessel should hang a little on the quarter of its leader, thus enabling a very close order without risk of accident; the proper signal to be made for each to take the starboard or port quarter of her leader, or to alternate, as the case might require. The formation for attack being as near a bow and quarter line as the circumstances permit, will be probably something between the line and the column, never reaching either limit, but adopting the course between the two that will tend to draw the fleet along one flank of the enemy; the line of bearing of the fleet being at an angle of about 45° with that of the enemy, rarely being parallel to his, and never at right angles; the course of the vessels always being brought nearly or directly opposite to that of the enemy when within ramming distance, that is, presenting ram to ram.

Strategy may require us to attempt the complete destruction of the enemy and thus somewhat modify our tactics. Our fleet may be masking the enemy's while we have another engaged in blockading, bombarding a fortified port, or forcing a landing; in such cases we could not afford to allow a large proportion of his fleet to escape, even if we destroyed the remainder. We must bring his entire fleet into a decisive engagement. Now, while preferring to start with an artillery combat if we are certain of preventing an escape, should there be any uncertainty, we must bring the ram into play; but even then we should be guided as in the first two propositions, and if he be in column, charge so as to bring the head of it at our center; and if he be in an extended formation, charge with our center abreast one portion of the line. In both cases we shall concentrate our fire upon the selected point, the only difference being that we must make greater efforts to ram in the charge. If we have superior speed, or have a sufficient force of swift torpedo-boats and rams to force a fleeing enemy to turn, then we may endeavor to injure his flank vessels with artillery before charging.

Again, strategy may require us to avoid for the time a decisive battle. Our fleet may be opposed by the masking fleet of the enemy, while he has another fleet engaged in blockading or attacking one

of our fortified ports or endeavoring to force a landing of troops. If we meet the combined fleets it must be our endeavor to prevent him from separating and engaging us with one fleet while the other fleet proceeds about its undertaking. If he succeeds in opposing us with his masking fleet alone, we must endeavor to escape from this fleet without too great a sacrifice, and then proceed to interrupt the operations of the other fleet. In neither case can we afford to risk a decisive engagement at once. In the first case we should run the risk of being overwhelmed by a superior force, and in the second, even if we should defeat the masking fleet, it would be at the risk of so crippling our own vessels as to leave his remaining fleet free to carry out his hostile intentions. Strategy here requires us to play a waiting game. In the case of the combined fleet we must proceed against them with our cruisers well in advance, our battle-ships next, with rams and torpedo-boats in the rear. Push forward the protected cruisers to resist the advance, as a game of long bowls with its chances of accident, we being near our repair shops, is in our favor. Let them fall back only when too closely pressed by a superior force, being careful to keep beyond the range of rapid-fire and machine guns. When they fall back they will disclose our line of battle, which will retire when the advance of the battle-ships of the enemy threatens to bring on a general engagement. Encourage the enemy by every means in our power to expend ammunition and fuel. At night bring forward the rams and torpedo-boats. By risking some of these and sustaining the attack with one or two battle-ships or armored cruisers, fast ones, the enemy may be forced into expending considerable ammunition. These attacks need not be pushed home and can be undertaken advantageously with but little idea of damaging the enemy's vessels, but undertaken mainly with the expectation of forcing him to reduce his supply of ammunition, a most serious thing for any fleet undertaking a distant expedition, for not only must reserve supplies of ammunition and fuel be carried with the fleet, but also the vessels must have time and opportunity to refill. The enemy would be able probably to defeat a real attack from torpedo-boats and rams, with the aid of electric lights and rapid-fire guns, but he will be more than human if he does not fire away when they are first sighted and before they incur imminent danger, especially if he be stirred up by a few large torpedoes from a dynamite cruiser. Here will be one use of a torpedo-boat designed to carry pneumatic guns, for at four thousand yards distance one could throw in among the fleet enormous charges of dynamite, and even if they failed to damage the

vessels their moral effect must be great. It will certainly require skillfully executed manœuvres to harass the enemy and yet prevent a general engagement; but after all it is only a question of ratios. At the speed of modern vessels, the enemy pressing steadily onwards, the speed of our retreat must be great and yet it must not become a flight. The ratio of the speeds must be carefully regulated so as to check the enemy and then avoid him. If he makes hot pursuit he may be made to cover much ground, with the consequent expenditure of fuel, by frequent changes of direction. The enemy's fleet would be likely to have with it a number of auxiliaries to carry coal, ammunition, and possibly troops, and the expedition might be seriously crippled by the destruction of these vessels. Many attempts might be made for this purpose both during the day and at night. Cruisers might be sent around the flanks if the unarmored vessels of the enemy kept well in the rear; torpedo-boats and rams might get around the flanks or through the fleet at night, or our fleet might charge through the fleet of the enemy and seriously damage the auxiliaries before they could escape. After a false attack had been made on the fleet with torpedo-boats, a second one might be made and pressed home, being closely followed by our battle-ships, which, charging through the enemy's line, could attack the transports, etc., with every hope of destroying them before their own battle-ships could come to the rescue.*

If our fleet is masked by the enemy either by being caught or pressed into port, then it must make every endeavor to escape the masking fleet so as to attack the active fleet of the enemy. It then becomes a matter of escaping blockade, the only question being whether it would be advisable to escape singly or in fleet. Single vessels might escape and again combine at some selected rendezvous, but such a separation of the fleet would be dangerous ordinarily and might result in disaster. The fleet should attempt to force their way out together. By repeated attacks with torpedo-boats and false alarms created by apparent attempts to escape, the enemy can be continually harassed; he will be forced eventually to send some of his fleet away for coal, and possibly for ammunition. Then let the fleet seize the proper moment, possibly a dark night or during bad weather, and, attacking first with torpedo-boats, push through with the fleet.* The harbor may be such that it will be necessary to have

*This is one of the few occasions when torpedo-boats would be used first in an attack; they being sent ahead to soften the enemy's line and make the charge through practicable.

range lights showing to guide the fleet. Should this be the case, it would be well to show lights in this vicinity for several nights before the attempt to escape is made, and pretend to signal with them to boats or vessels in the harbor, so that when really used the enemy would not know their character. Otherwise a vigilant enemy would readily pick up ranges leading out of the harbor and know that a real attempt was to be made. Perhaps the most difficult case to encounter would be where the masking fleet could seize a harbor near the fleet that they were masking, and, without attempting to blockade our fleet, merely keep up a close observation with cruisers and torpedo-boats, being ready to slip and pursue when our vessels attempted to escape. But even here we could make a vigorous attack upon his observation vessels, and frequently make a pretence of escaping, forcing him to pursue, until the proper moment came for an actual attempt. Certainly there would be ample opportunities for the exercise of the talents of skillful seamen and tacticians on both sides. If the enemy equaled us in these points, we should escape unless his fleet was much the stronger. Having escaped, we must attack his other fleet and prevent the accomplishment of his designs. Our fleet would probably be in telegraphic communiction with the point attacked, and we might be able so to time our escape as to reach the threatened point at a time when his fleet was engaged with the fortifications and when we could strike him at a disadvantage. Having made our escape, we should have but little time to wait before attacking, for, as soon as the masking fleet lost touch of ours it would naturally look for us near the point attacked. Now comes the moment in which the bold commander will always delight; there is no longer room for hesitation, the points for and against an attack can no longer be weighed, we must make a vigorous attack, and, damaging the enemy, either drive him off or cut through to the harbor defenses. If we fail to drive him off or so injure his fleet as to prevent the further prosecution of his design, we are defeated, and it will be no advantage to the country to preserve the vessels from harm if their fighting strength is nullified. Heretofore we have refused a decisive engagement to preserve our vessels for this crucial moment; now we must do the greatest possible damage to the enemy even if we sink our entire fleet. But we should command success, for if our attack be well timed he must not only engage the forts but must also be caught between the fire of our harbor defenses and our fleet. At the moment when the enemy has pushed close in to attack the forts or is trying to pass into the harbor, then if our fleet strike him in the rear we shall

have done the best that can be expected of strategy and tactics, and our fate will depend upon our seamanship and strength.

We may have more than eight battle-ships cruising together; if they are over ten, I believe they can be more successfully fought if they are divided into two fleets. When the number of auxiliaries accompanying a fleet is taken into account, and the extended line of battle, even when in very close order, is considered, it would seem that, if too close a combination were used, tactics would be almost impossible, and the difficulty of seeing and obeying signals would lead to confusion. If sailing together, they should be divided into separate fleets and manœuvred separately, but having the same object in view. When together, the ordinary sailing order should be in parallel lines of bearing, the right vessel of the rear fleet being directly astern of the right vessel of the leading fleet, the distance between lines being at least one-half a mile. This will make an excellent formation for battle, unless the enemy advance with extended front, and from want of speed or because of our position we cannot charge through his line. If this be the case the fleets must be so manœuvred as to extend our front to give a strong line of fire. If we can charge through an extended front of the enemy while we are in parallel lines, we should be able to destroy or disable some of his vessels. This formation combines the advantages of the column and the line, as we have depth with a sufficiently extended front to deliver a strong fire. The distance between lines should be enough to allow each preceding line to be well clear of the enemy before the following line charges through. The leading vessels should not attempt to ram unless forced by circumstances, or unexceptionable opportunities offer, so as to leave a clear space for the last line, which, after charging through, should turn and stick to the enemy and ram and use torpedo-boats freely, the leading line or lines turning when well clear of the enemy and moving in such a direction as to attack the remaining vessels of the enemy not heretofore closely engaged. If the enemy form his fleet in compact order, then we must endeavor to draw our line across his front and strike him in the flank if possible. In handling a large number of vessels the reserve fleet will be a most important point, and the commander who has his reserve well in hand and can throw it upon the enemy when his formation is confused by a close attack should win the day.

In this discussion of naval tactics there is no attempt to provide for many of the cases that may arise in battle; it is only intended to

show that there still is room in naval warfare for tactics, and the chances will favor the tactician, other things being equal; that the gun first, and afterwards the ram, are the principal weapons, and that the fundamental principle of naval as of military tactics is to combine our force against a portion of the enemy. The evolutions and manœuvres must be simple, the tactics must be plain; the enemy may readily answer every move, but should he fail to be a tactician or make a wrong move we can seize the advantage and should defeat him. On the other hand, if we fail to adopt any tactics and rely on the prowess of individual vessels, our fleet will be a confused mass, and a skillful enemy will surely hold us at a great disadvantage.

There have been great strides made in naval weapons, but in looking over the field with an eye to tactics, it appears to me that the love of novelty and invention has carried us too far in both guns and torpedoes. Our high-power guns are magnificent weapons, but are they entirely designed to meet the work they must accomplish? Their great range is of no advantage in an ordinary naval combat, as the necessarily limited supply of ammunition will prevent us from firing at an enemy until the probable chances of a hit are within reasonable limits. If, as seems highly reasonable, the opening range hereafter will be about 2000 yards, cannot we save in weight of gun without greatly lessening the penetration or increasing the height of the trajectory, diminishing the efficacy and the accuracy of fire? As all know, this weight might be used to great advantage in many ways—in more guns, more ammunition, more armor, or more coal. The supposed terrible effect of torpedoes has led to their adoption on board any and every vessel. It seems to me that torpedoes on the ordinary type of vessels are likely to prove more harmful to friend than to foe; that their main use should be on specially designed vessels; for in armored vessels and above-water tubes, and in any kind of tube in unarmored vessels, the rain of missiles from rapid-fire and machine guns that will be poured in before the range of the torpedoes is reached will make it probable that they will explode on board, while only possible that they will explode under the enemy. The chances should be at least the other way before a weapon is generally adopted.

Our great need is to study strategy closely in time of peace, and to adopt simple formations and evolutions, in order to ascertain carefully the limits of our weapons. Much must be left to conjecture, and can be demonstrated only in battle; and even then

tactics can only be outlined, a few broad general principles laid down, and the rest left to the admiral of the fleet. It would be impossible to provide for every case, and he should not be hampered with binding instructions. With the general plan of attack in his mind, the tactician will be ready to take advantage of every mistake of his opponent, and will hold victory in his grasp.

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

ARMOR FOR SHIPS: ITS USES AND ITS NATURE.

By Sir Nathaniel Barnaby, K. C. B.

[Reprinted from the Proceedings of the Institution of Civil Engineers.]

At the commencement of the Russian war in 1853-4, several points in relation to the defense of ships against projectiles had been established, by experiment, to the full satisfaction of the naval experts. It had been settled that war-ships must be built of wood; iron was an altogether unsuitable material, as the captain of H. M. S. Excellent reported, 1850, that "whether iron vessels are of a slight or substantial construction, iron is not a material calculated for ships of war." Seventeen iron ships, which had been in process of construction for fighting purposes, were thereupon condemned as useless for war service. It had been decided that protection by armor-plates was of no value. Iron plates 6 inches thick, placed in front of the wood, had failed to protect it. Admiral Sir Thomas Hastings had reported that wrought-iron plates (6 inches thick) riveted together and fixed over the planking of a ship's side, would give no protection at 400 yards against shot fired with 10-pound charges from 8-inch guns and from heavy 32-pounders. The favorite guns were therefore shell-guns.

The armament of a three-decker of 121 guns consisted of one-half of 65-cwt. shell-guns and one-half of 32-pounders, with one 68-pounder pivot-gun. The shell-guns were placed on the lower and middle decks. In a two-decked ship the lower deck was armed throughout with shell-guns, and the other decks with 32-pounders of from 42 to 58 cwt. In some cases the main deck was partially armed with shell-guns. The frigates were armed with 8-inch 65-cwt. shell-guns on the main deck and with 32-pounders on the upper deck. All shot were of cast-iron. No one knew what the result of an action

with these shell-guns would be, but all agreed that the struggle would be short.

In the autumn of 1853 a Turkish fleet, of seven frigates and some smaller vessels, was attacked at Sinope by a Russian fleet of six line-of-battle ships (three of them first-rates), two frigates, and two or three smaller vessels. The Turkish ships had no shell-guns. They were armed with 24-pounder shot-guns. In less than five minutes a Russian ship of the line, Grand Duke Constantine, destroyed a battery and a Turkish frigate anchored near it, chiefly by shell from the lower deck. A short time afterwards the Ville-de-Paris, another Russian ship of the line, blew up, by shells, another Turkish frigate. Of the crews in the Turkish fleet, above three thousand perished. Of the ships, only one small steamer escaped.

In the allied attack upon the forts at Sebastopol in October, 1854, the Agamemnon, London, Sans Pareil, and Albion took up positions within 1000 yards of Fort Constantine, which was armed with one hundred and four of the heaviest guns and was supported by three other smaller heavily armed batteries. In about an hour the Albion, London, and Sans Pareil were so injured that they had to haul off to a greater distance. The Sans Pareil and London soon afterwards resumed their stations to support the Agamemnon; the Rodney, Queen, Bellerophon, and Arethusa also came to her support. The Queen was almost immediately set on fire by a shell, and had to be towed out of action. The Agamemnon and the remaining vessels kept up the cannonade, which had commenced at two o'clock P. M., until it was dark, when they drew off. They had in all three hundred and ten men killed and wounded. The Albion and Arethusa were so damaged that they had to be sent to Malta for repairs. The Albion, Retribution, London, and Queen had all been on fire, chiefly from the effects of shells with time-fuzes.

The destructive effect of the shells and other incendiary projectiles used by the Russians in these engagements led to the immediate use of armor, notwithstanding the previous adverse decisions of English gunnery officers. The adoption of armor led at once to the use of iron in the hull by English architects, in spite of the series of experiments at Portsmouth which have been referred to, and which had brought about the condemnation of the fleet of seventeen iron ships.

The first move in the direction of armored plating was made by the French, in the month succeeding the unsuccessful attack of the

allied fleets upon Sebastopol. In an imperial order to the French Minister of Marine, dated from St. Cloud, 16th November, 1854, the Emperor Napoleon III. pointed out that in warfare there must be, in addition to courage and ability, even chances. Actions on land are avoided so long as there is no chance of success. So in naval warfare, if the fleet were risked, it would be in the hope of destroying that of the enemy. An enormous capital is hazarded in order to destroy that which has cost the enemy as much. But, he went on to say, so soon as the fleet is employed in the attack of a fortification the proportions are entirely altered, for not only will a ship be found inferior to a land battery, because a ship offers a large object to strike while the land battery occupies but little space and is protected by parapets, but also the stake is materially different. So it happened that in the Black Sea twenty-five thousand sailors and three thousand guns could not seriously injure the Russian fortifications, and that indecisive attacks were made at other places, entailing serious damage to the ships without doing any material harm to the enemy. Under the existing conditions risks were incurred for nothing. If the ships threw their projectiles at 2000 metres they consumed their ammunition at a dead loss, and gave a false idea of the power of the fleet. If they approached nearer, they exposed the state to sacrifices too considerable in proportion to the object in view, for it would generally be perfectly senseless to risk the loss of a fleet for the destruction of a few forts. To remove this difficulty he proposed to create "*une flotte de siège*," capable of producing decisive effects, and at the same time of lessening to the state the chances of loss of men and money. The course taken to meet the Emperor's views was to build floating batteries with numerous light broadside guns, and covered from end to end with iron armor-plates.

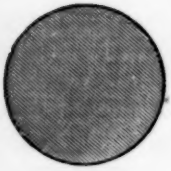
Table I. shows what changes in distribution armor has undergone since 1854.

There are two periods. In the first period the armor was employed, as has been seen, to make the chances of loss of capital more nearly even in a contest between ships and forts. The ships or floating batteries were to be small, numerous, and armored. In the second period the armor was to protect sea-going ships in contests with the sea-going ships of an enemy. That period is still current, and has reached a fifth phase, a phase which is in fact only a repetition of the first. The illustrations have been confined to the ships of the French navy, as the English are in no way responsible for them and can perhaps regard them dispassionately.

TABLE I.—PHASES OF ARMOR.

First Period, Floating Batteries, 1854–58.

Second Period, 1858–1888.



GLOIRE.

1856, 1st Phase. Armor (side), 4¾ inches.
5500 tons.
Speed, 12¾ knots.
Percentage of weight devoted to armor, 15.

MARENGO.

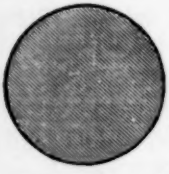
1869, 2d Phase. Armor (side), 7 inches.
7750 tons.
Speed, 13½ knots.
Percentage of weight devoted to armor, 17.

BAUDIN.

1880, 3d Phase. Armor (side, etc.), 22 inches.
11,200 tons.
Speed, 15 knots.
Percentage of weight devoted to armor, 33.

TAGE.

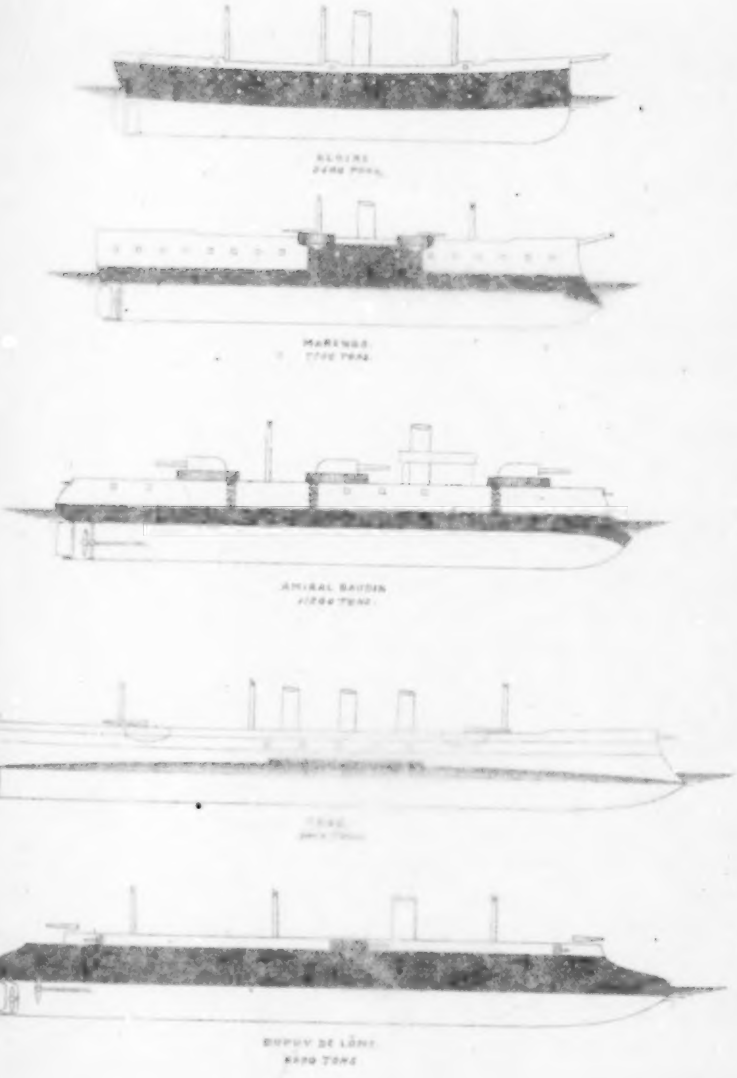
1886, 4th Phase. Armor (deck), 3 inches.
7000 tons.
Speed, 19 knots.
Percentage of weight devoted to armor, 14.



DUPUY DE LÔME.

1888, Return to 1st phase. Armor (side), 4 inches.
6300 tons.
Speed, 20 knots.
Percentage of weight devoted to armor, 15.

The first phase of the second period was entered upon in 1860, when a sea-going ship, the Gloire, was launched, clothed from end to end in exposed parts with iron armor. Some of this armor, 4¾ inches thick, was impenetrable to the heaviest guns then carried at sea. The second phase soon followed. It was marked by growth

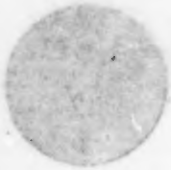


To face p. 94

TABLE I.—PHASES OF ARMOR.

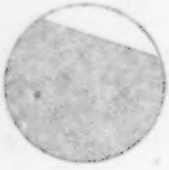
First Period, Floating Batteries, 1854–58.

Second Period, 1858–1888.



GLOIRE.

1858, 1st Phase. Armor (side), 4¼ inches.
5500 tons.
Speed, 12¼ knots.
Percentage of weight devoted to armor, 15.



MARENGO.

1869, 2d Phase. Armor (side), 7 inches.
7750 tons.
Speed, 13½ knots.
Percentage of weight devoted to armor, 17.

BAUDIN.

1880, 3d Phase. Armor (side, etc.), 22 inches.
11,200 tons.
Speed, 15 knots.
Percentage of weight devoted to armor, 33.

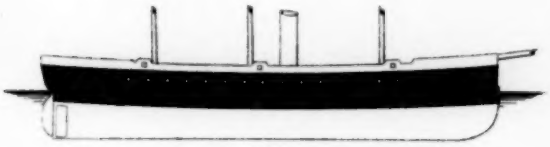
TAGE.

1886, 4th Phase. Armor (deck), 3 inches.
7000 tons.
Speed, 19 knots.
Percentage of weight devoted to armor, 14.

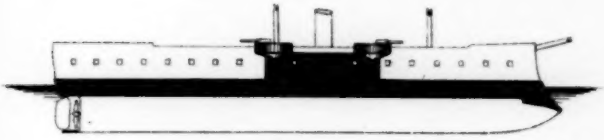
DUPUY DE LÔME.

1888, Return to 1st phase. Armor (side), 4 inches.
6300 tons.
Speed, 20 knots.
Percentage of weight devoted to armor, 15.

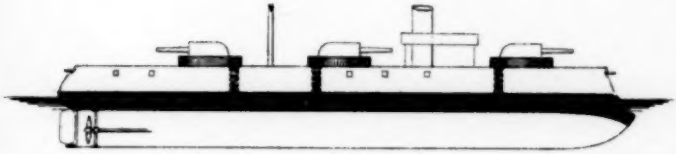
The first phase of the second period was entered upon in 1860, when a sea-going ship, the Gloire, was launched, clothed from end to end in exposed parts with iron armor. Some of this armor, 4¼ inches thick, was impenetrable to the heaviest guns then carried at sea. The second phase soon followed. It was marked by growth



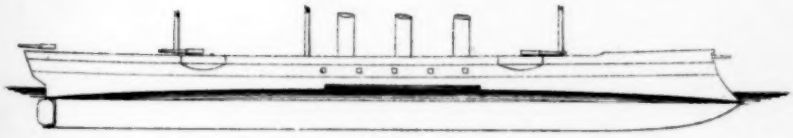
GLOIRE
5600 TONS.



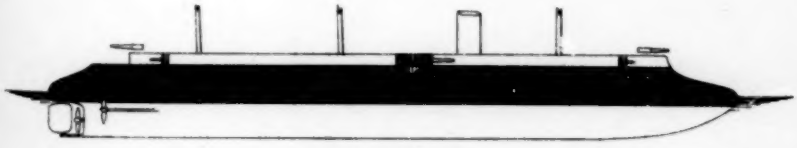
MARENGO.
7750 TONS.



AMIRAL BAUDIN
11300 TONS.



TAGE.
7000 TONS.



DUPUY DE LÔME.
6300 TONS.

To face p. 94.

in the weight of the gun, by improvements in the powder, and by alterations in the form and character of the projectile to enable it to perforate armor. It was characterized, on the other hand, by increases in the thickness of the armor and by improvements in its quality. But the ship did not increase in size. The British sea-going ironclads of the first phase, commenced in 1861, are larger than those in the Admiral and Victoria classes built twenty-five years later.

To resist growth in the size of the ships for twenty-five years, while the gun and the armor were making strides in advance, was no easy matter. And, while this growth in the gun and the armor went on, torpedoes were introduced, and torpedo-boats. Higher speeds became thereupon necessary and had to be given to the ships.

In the second phase of this second period the French ships underwent a remarkable change, rendered necessary by the foregoing considerations. The French divided their battery, as the English had already done, into two parts. They continued to protect one part with armor, and the other they left unprotected. The relative extent of these two batteries was subjected to continual modifications. The number of guns protected became less and less in succeeding ships, while the number of those left unprotected increased.

At last, taking the Amiral Baudin for example, launched in 1883, and the Formidable, launched in 1885, there are from eight to sixteen machine-guns and twelve 5½-ton guns fought without armor-cover from any direction. The only guns having any armor protection are three in number, each of 75 tons, and these are protected only as to the carriage of the gun; its breech, its charge, and its loaders are without any armor-cover. The signal stations and the officers in command are also unprotected by armor. Admiral Touchard, the French Controller of the Navy in 1873, gave the reasons for this reduction in armor. Referring to the Gloire, Marengo, Hercules, and Koenig Wilhelm, he says: "These, then, are the instruments for fleet-fighting of to-day. Is it to be believed that they will continue to occupy the first position, that they will be the *ne plus ultra?* No, for the gun goes on always increasing in power; and in France, as in England, Russia, and Prussia, we are no longer contented with guns of 10 and 11 inches—we go up to 12 and 13 inches, and there are laid down in the dockyards ships for fleet-fighting plated with armor from 9½ to 12 inches thick, and from 9000 to 10,000 tons displacement. Where shall we stop in this

strife? Where will it end? I see the end," he goes on to say, "in the abandonment of armor for the guns. Sooner or later this will be the end for the armored cruising ship. Let us admit, if you will," he says, "that the battery should for the future be plated with armor of 10 inches, as it soon will be, the question of abandoning it will nevertheless be resumed upon these two considerations: 1. Is battery armor of 10 inches penetrable? 2. If it is penetrable, does it not become rather a danger than a protection?" And then he goes on to say: "And now let us see what will take place in a battle between fleets. The squadrons being in order of battle, if both freely accept the contest, there will be collision by ramming, either with or without preliminaries. In any case it will suffice that one of the two should be resolved for it to make ramming the first act; let us mark the opening phase of the fight. The combatants advancing towards each other would be ranged in one line, or in several lines, or in squadrons; but, whatever the order of battle, there will be formidable collisions and grinding of the sides; they will cross each other's courses, and then, putting the tiller hard over, will return to the encounter. Again will they strike and again pass on. Woe to the vessel, which, disabled by the first attack, or turning less quickly than her adversary, exposes her flank! Like the Re d'Italia at Lissa, she will be sunk by a single blow.

"It is here—in this initial phase—the ships perpetually fouling each other, that the gun appears on the scene in all its might. The manœuvre is foreseen. A single order, clear, concise, energetic, follows in three words: 'Prepare for ramming.' At this command the guns are pointed low; the captain of each, his eye fixed on the sights, with bent body and extended arm, waits! He watches the moment when his adversary will pass before the muzzle of his gun—the moment, fleeting as the light, which he must seize for firing. Silent and motionless, each man is at his post, but lying full length upon the deck. The captain alone remains erect; suddenly the guns and musketry burst forth, and the vessels crash into each other with their sharp-pointed prows, and gliding by each other prolong the contact along their sides until they reach their sterns, which they avoid in order to protect their rudders and screws. After this first encounter, the combat will always be carried on at short distance, if not broadside to broadside, the gun and rapidity of evolution playing the principal *rôle*."

At the same date Admiral Sir John Dalrymple Hay, who had been President of the the Armor-plate Committee, said:

"I come to the conclusion at which Admiral Touchard has arrived, that it is impossible to conceive of any ship but a ship of the very first class, ships of which I do not think many are likely to be constructed, which will be entirely and completely covered with impenetrable armor. If the armor is not impenetrable, then it is worse than useless."

Of the several parts demanding protection he gave the following, with his opinion of the order in which they stood as to importance: 1. The magazine; 2. The propelling machinery; 3. The mounting for the heavy guns; 4. The water-line; 5. The men.

The commander-in-chief at Portsmouth in 1876, Admiral Sir George Elliot, said, in an address circulated among Members of Parliament, that vast sums of money had been uselessly expended in clothing ships with outside armor, because this feature of protection against the gun attack had not been submitted from time to time to the independent judgment of competent critics. He considered that "the evidence of the superiority of the gun, and the development of the efficacy of the ram and the torpedo, had deprived us of sufficient excuse of late years to continue to fight the losing game of armor against guns." He complained that the Admiralty had treated the ram and torpedo attack as secondary, and that its efforts should have been directed toward the protection of ships under the water-line rather than above it.

These French ships, Amiral Baudin and Formidable, mark the close of the third phase of the second period.

The fourth phase in the French navy, marking the total abandonment of side-armor in fighting ships of considerable size, was not reached until ten years after Admiral Sir George Elliot had declared it to be necessary to abandon side-armor, even in the largest ships, in the terms quoted above. The building of the Tage marks this phase. This vessel, called a protected cruiser, is far larger than the fully armored line-of-battle ships of 1858, and is armed with sixteen guns, capable of perforating 8 inches to 10 inches of iron armor. Although much larger than the Conqueror or Hero, the only armor is the bomb-proof deck over the machinery and magazines.

Writing four years ago an article on shipbuilding for the "Encyclopædia Britannica," the author said:

"The use of armor has arrested the development of the shell. But it is not inconceivable that its abandonment in front of the long batteries of guns in the French and Italian ships will invite shell

attack, and make existence in such batteries, if they are at all crowded, once more intolerable. It remains to be seen whether in that case exposure will be accepted, or a new demand made for armor, at least against the magazine gun and the quick-firing gun. If exposure is accepted, it will be on the ground that the number of men at the guns is now very few, that the gun positions are numerous and the fire rapid, and that, if the guns had once more to be fought through ports in armor, the number of gun positions would be reduced, and the fragments of their own walls, when struck by heavy projectiles, would be more damaging than the projectiles of the enemy."

What is here called the fifth phase is the fulfillment in 1888 of this anticipation of 1885. There has been a new demand made for armor against the magazine gun, the quick-firing gun, and the shells with high explosives, and the French are once more clothing their ships with thin armor.

Having thus rapidly traced the history of the application of armor to ships-of-war during the last forty years, the author will now examine the weapons.

There can be no doubt that the immediate cause of the change in French policy is the assumption that the shells charged with gun-cotton, melinite, bellite, lyddite, or some other numerous high explosives, will be fired from ordinary guns.

Shells with bursting charges of gunpowder are ineffective against thick armor. To perforate such armor, the walls of the shells must be made so strong that the contained gunpowder charge would fail to burst them.

More than five years ago the Italian government experimented with gun-cotton as a bursting charge for shell. At about the same date English artillerists were endeavoring to perfect a delayed action fuze, so as to delay the bursting of the shell containing high explosives until after the armor had been perforated. Since then every government appears to have had experience, at the proof butts, of the difficulty of making a trustworthy controllable fuze for this purpose. When this fuze has been established, shells charged with high explosives will come under control, because bellite and lyddite appear to be in themselves perfectly manageable. The French authorities have satisfied themselves that they have brought melinite under control. The introduction of 4-inch side-armor over the batteries proves this. The quick-firing gun will not account for it, because 4-inch armor is perforable at 1000 yards by the 14-pounder

quick-firing guns; and here quick-firing guns, 45-pounders, 55-pounders, and 100-pounders, are now being prepared. Moreover, this 4-inch armor will make it even easier for common shells of large caliber, with bursting charges of gunpowder, to be exploded among the guns' crews. The fragments of the armored walls will be in themselves very destructive.

But it has been ascertained that a delayed-action fuze is not at present procurable, and that the shock caused by 4-inch armor will explode shells with high explosives, fired from moderate-sized guns, on striking. This is why 4-inch armor has been adopted.

The effect of a burst between decks of these high explosives is a matter of experience to some. The French have pursued the subject diligently, and they apparently consider it better to have the armored walls broken into fragments and scattered about the decks than to endure the explosion of melinite between decks, breaking the beams and frames, upsetting the guns, and paralyzing the crews. But if this is so, and there be any likelihood of having to attack ships like the large French battle-ships Amiral Baudin, Formidable, Amiral Duperré, and others, it is of the utmost importance to be prepared to make such an attack.

The author knows, from an inspection of the drawings of targets which have been experimented upon with a single charge of gun-cotton, that a number of heavy 16-inch deck beams, covering a length of deck of 12 feet, have been broken completely across and lifted 12 feet above the original level. They were broken across immediately over the charge, and from 10 to 14 feet away from this point (at the knees) they were broken again, so that the decks and beams were piled up in a huge wreck at least 12 feet high.

When the large undefended structures in the French ships are considered, the seriousness of this attack becomes evident. And it is the artillerist who must be first impressed. It is of more consequence to be able to inflict damage in war than to be able to resist it. The best defense is to be found in a vigorous attack.

It must be understood that the powerful ships in modern navies are not protected, so far as their batteries are concerned, by the armor which the French think necessary. They are unarmored from their lower decks upwards.

And now to examine the question as to what is likely to be the outcome of this re-introduction of side armor. Is there any chance that there will be an approximation to finality in the use of such armor?

Look first at the quick-firing gun and see what it will be capable of doing against 4-inch armor. Prior to the introduction of the machine gun and the quick-firing gun, the most rapid fire of guns, capable of perforating an unarmored side, did not reach two rounds per minute. The introduction of the Nordenfelt 1-inch machine gun with four barrels raised the rapidity of aimed fire with steel bullets to 120 rounds per minute. These bullets perforate a plate ¾ inch thick at 200 yards. The single-barrelled quick-firing gun of 1.85 inch caliber, firing 3-pound shot or shell, can get off fifteen aimed rounds per minute. The shot from this gun perforates a steel plate 1.8 inch thick at 1000 yards. The 2.2 inches single-barrelled quick-firing gun throws 6-pound steel shells at the rate of fifteen aimed rounds per minute, perforating more than 2½ inches of steel at 1000 yards, and 4 inches at close range. Armor-piercing projectiles from quick-firing guns will soon follow. The 6-inch 100-pounder is capable of perforating nearly 10½ inches of iron armor at 1000 yards range, and with steel shell can just get through 9 inches of compound armor at 200 yards. From five to six aimed rounds can be got off from this gun per minute. A further development of the quick-firing system is the automatic gun.

The 3-pounder, 6-pounder, and 50-pounder automatic guns can be fired, with rough aiming at short ranges, at the rate of fifty, thirty-six, and fifteen rounds per minute. With deliberate aim they can be fired with nearly half that rapidity.

It is certain that, apart altogether from these quick-firing guns, it will only be necessary to put up targets of this thin armor and expose them to the fire of heavy projectiles (shot and shell) in order to show the frightful wreck behind the target which occurred years ago, and which led to thicker and ever thicker armor. But there will be this difference in favor of the gun, that the projectiles are heavier and stronger, the velocities are higher, and the explosives are more powerful.

Experiments have hitherto indicated the certainty that armor will be blown in by charges exploded against it, and that bursting charges with high explosives will be carried through armor probably 12 or 14 inches thick. Now come the questions for the naval administration:

1. Is full advantage to be taken of these high explosives in any war which may break out within the next two or three years? To this question the author can give no answer.

2. How is the new attack to be met in ships? The answer of the French has been seen. They would, if they could, cover their batteries with 4-inch armor.

Another defense is to take care to have a superiority of fire. Any armor carried by an adversary reduces the number of effective shots which can be delivered, because heavier guns must be employed and the fire must be slower. But 4-inch armor is so penetrable that there will be no difficulty in delivering effective blows. Moreover, the fact that the enemy has armor reduces his armament very seriously. If he should have to fire the guns through port-holes cut in the armor, he will hardly be able to secure his battery from the intrusion of the projectiles against which he has armored himself. In the French ship Dupuy de Lôme no guns are fired through ports. The guns are mounted on an unprotected upper deck. The armor protects them only by keeping out the high explosive shell which might burst under them.

A third way of meeting this new attack is to multiply the ships with the same expenditure of capital, and thus to limit the loss of capital in a disaster arising from the use of these powerful agents of destruction. If this third way is admissible, it is most clearly to the advantage of England to pursue it. This country, above all nations, needs numbers of ships.

To other powers the significance of individual ships is of most concern. To the English it is important above all things to be present in many places with ships capable of attacking any enemy. For every ship-of-war having 14 knots speed now in the British navy there are one hundred and thirty-three ships to protect. (Table II.)

TABLE II.

	England.	France.	Italy.	Russia.	Germany.	United States.
Ships-of-war capable of steaming upwards of 14 knots an hour.....	92	68	43	22	34	12
Number of merchant ships of 100 tons and upwards to each of above vessels	133	22	40	56	61	303
Merchant steamers of 14 knots speed and upwards, and of 1500 (gross) tons measurement and upwards.....	87	22	4	..	12	..

If the British government determines to spend money upon invulnerable ships, the difficulty in increasing our relative numbers will be perpetually growing. There is no difficulty, except in finding the money, in making an invulnerable ship. Ships can be built and navigated, which no torpedo, nor ram, nor gun which can be worked from any ship now in existence can fatally wound. In such a ship every man may be absolutely protected, high explosives notwithstanding. But there will be so few of them that commerce and the colonies may be lost for want of ships, and there will only be the satisfaction that the sailors have been protected in such ships as exist.

In order to put forward in a concrete form the author's view as to the type of fighting ship most suitable for the present needs of the British navy, he has brought forward a design. It is for a ship of 3200 tons displacement, costing one-fourth of the so-called first-class battle-ship of to-day. A sufficient number of ships of this type could probably be built and armed in two years, the guns being included in the contract. It may be said that nothing can be done upon such dimensions and such cost which can entitle the ship to be called a battle-ship. It may be well remembered that the seventy-four-gun line-of-battle ship of fifty years ago had a total displacement of only 3000 tons, and that the eighty-gun ship of the same period had only 3500 tons. This design comes between the two, and will cost as much as three seventy-four-gun ships, although, as has been already said, it will only cost one-fourth of the modern first-class battle-ship.

It is difficult to get the sailor to appreciate a money basis. He has to fight in the ships. He sees that his personal chances of life in the smaller ship are less than they would be in the ship costing four times the money, and he naturally values his life and his chances of personal victory more than he does gold. He cannot be expected to see that if four British ships, costing for the four a million of money, destroy or capture one ship of the enemy costing the same amount, at the sacrifice by foundering of the ship which he might command, that that would be an altogether good result.

It is necessary to bring to the front the enormous increase in the value of the material of war which is entrusted to each captain and to each man in a modern ship. In the line-of-battle ship of fifty years ago, the value of the material for a single command would have been about £100,000, and the value per man in the crews of such ships not more than £150. In the ironclad of 12,000 tons of to-day, the value of ten of the former line-of-battle ships is entrusted

to each captain, and not less than £2000 to each man in the crew. In the ship of 3200 tons, which is furnished in illustration of the principle of giving preference to numbers of ships rather than to individual costliness, each captain would still control an expenditure twice that required for the line-of-battle ship of fifty years ago, and each man in the crew would represent from £1000 to £1500.

The description of the ship may be very brief.

The speed suggested is 17 knots an hour on the measured mile as a minimum. This is two knots higher than the speed of the largest armored ships of France.

There is an under-water deck. It is kept wholly under water, and may be, upon the dimensions shown (but with some corresponding variations in displacement), of thicknesses of from 1 inch to 3 inches. This deck is covered from end to end by a solid raft of packing material manufactured by the Woodite Company, which rises above water several feet at the sides and six inches in the middle. This packing material is practically non-absorbent of water. It will exclude for twenty-four hours 96 per cent of the water which would enter any empty compartment. It requires an appropriation of weight of from 4 to 5 per cent of the displacement. By this means the floating power of the ship is preserved against sudden destruction under artillery fire. The raft-body can only be slowly destroyed.

For the defense of the fighting position, steel-faced armor 9 inches thick is employed. Within this there is further armor protection, 6 inches thick, over the directing station for the officers.

The order in which protection is given is as follows:

1. Propelling and steering machinery and magazines.
2. Floating power.
3. Officers at their fighting stations.
4. Guns and gunners.

In close action the whole crew may be under armored cover. The armament is central, with an unrestricted all-around fire from every gun. The guns may either be a pair of 22-ton armor-piercing guns, as shown, or a greater number of lighter guns for firing high explosive shells. In either case the mounting is revolved, and the guns are trained and fired by the officers in the central position. The gunners have only to load the gun in their own separate compartment of the revolving mounting and to connect the firing wires.

The design and the estimated cost of the ship have been prepared

by the Naval Construction and Armaments Company, assisted by Sir Joseph Whitworth & Co.

What the author desires to say is that such a ship may attack fortresses with as good a chance of immunity from destruction from torpedoes and rams as the ship of 12,000 tons; and for the same money there will be four ships to one. The same is true of the defense of ports. As to fighting at sea with other ships, each of these four ships will find perforable to its guns 99 per cent of the area of the sides of those armored ships which have side armor. The ships of 12,000 tons, armed with 67 and 69-ton guns, will find only one-half per cent more perforable to their guns. There are four batteries and eight heavy armor-piercing guns in the four ships, and only two batteries and four heavy armor-piercing guns in the 12,000-ton ship, which has cost as much. There are four captains for independent as well as for united action, four securities against breakdown or damage by the enemy, and the power of occupying four positions on the field against one in the 12,000-ton ship. The principle holds for ships of larger size, say one-third, or of one-half the cost of the largest ship of the enemy.

But the peculiar feature in this design, that is, a single central battery, becomes less advantageous as the ship is increased in size. It is, perhaps, only applicable with undoubted advantage where at least three ships and three batteries can be brought against the very large ship of the enemy, who may have as many as three armored positions in one ship.

If it should be said that this dispersion of force entails a risk of destruction in detail by encounters with units of greater force in the hands of the enemy, that argument simply goes to show that organizing skill will be required to ensure the presence of the united forces where they are needed.

The position is, that to satisfy the demand for superiority in individual ships, an expenditure of one million of money has been reached for a single-armed ship.

On examining the ship as the French ships have been examined, it will be discovered that they are most seriously exposed to the attack of the powerful weapons which are now in rapid course of development. The naval authorities have to decide for themselves whether they will concur in still further enlargement in individual ships, or will endeavor rather to meet them by combining the forces of smaller ships. It appears to the author that there is no difficulty in taking this latter course, and that it has many advantages.

The principle of subdivision is consistent with perfect seaworthiness, with a speed as high as that of the largest ships, with the control of weapons which can be used with fatal effect upon the most powerful ships of the enemy, and with such powers of endurance as will enable the smaller vessels to receive injuries from the largest ships without necessarily fatal results.

In this exposition of the uses of armor, it has become apparent that fighting ships must continue to use it. When armor is employed in the form of comparatively thin horizontal plating, experiment seems to have shown that steel, low in carbon, is the best material. When it is employed in the form of a wall, either upright or inclined, and comparatively thick, the value of a hard face becomes very marked.

There are three distinct modes of manufacturing thick armor. They are described by Mr. Alexander Wilson, the original inventor of compound armor, and the chairman of the firm of Charles Cammell & Co., as follows:

A large wrought-iron plate, built up of many thicknesses, is passed through the rolls, and is then, whilst red-hot, pushed horizontally into a huge iron casting-mould, revolving on trunnions. When the plate is securely fixed, the mould containing it is turned up into a vertical position and liquid steel is poured from a ladle into a trough, which distributes it in small streams into the cavity between one side of the wrought-iron plate and the side of the mould, precautions being taken to prevent it from flowing elsewhere. When the steel has become solid, the whole mass of iron and steel, which is fused together, is taken out of the mould, and after re-heating, again passed through the rolls until it is reduced to the thickness required. It is subsequently bent at the hydraulic press to the curvature of the ship, and is then placed on the planing or slotting-machines to be cut to the finished sizes, the drilling of the bolt-holes being the final operation. This is the plan pursued by Messrs. Charles Cammell & Co.

The method adopted by Sir J. Brown & Co. is somewhat different. It consists in taking a wrought-iron plate, after allowing it to cool, and placing a thin steel plate a few inches from its surface by means of wedge-plates round the three sides, small steel studs being placed at several points to prevent the two plates from coming too close to each other in the furnace. The whole mass is then heated, taken out of the furnace, and lifted by a crane vertically into the pit, where the molten steel is poured between the two plates from a ladle and

trough. The plate is afterwards rolled, or otherwise compressed, bent, and machined.

Mr. Wilson describes the successive phases of the manufacture of the forged steel plates at the Creusot works as follows:

1. The running off, by means of the Siemens furnace, of an ingot proportionate to the weight required for the plate when finished; the latter representing only about 55 to 60 per cent of the steel cast.

2. The heating of the mass in gas-furnaces, and the forging of the plate under the eighty-ton hammer.

3. The shaping, either by hammering or with the hydraulic press, followed by annealing in a coal furnace.

4. The trimming, either with a planer or a saw, when the metal is cold.

5. A first vertical oil-tempering at a high temperature, followed by another tempering at a lower temperature, and often by annealing.

6. The finishing of the plate by the planing off of the ends.

The most successful plate ever fired at in England or elsewhere, so far as the author can learn, was tested at Portsmouth on the 24th of March, 1888.

It is a steel-faced plate 10½ inches thick, manufactured according to their process by Charles Cammell & Co., and attacked by 6-inch forged steel shot of 100 pounds weight, and having a muzzle velocity of 1976 feet per second, and a striking energy of 2723 foot-tons.

The same firm manufactured, at the same time, a steel plate. Mr. Wilson says it is the "first steel plate which has ever withstood such a severe test without breaking up," and that certainly it has proved much superior to any plate manufactured at Creusot which has been subjected to artillery fire. It was tested, under similar conditions to the preceding one, at Portsmouth on the 19th of May, 1888.

Three shots were Holtzer forged steel shell, of 100 pounds weight, 17⅜ inches long; two were Palliser chilled cast-iron, of 98 pounds weight.

The Schneider plates have, he says, invariably cracked through at the second shot, and in the generality of cases at the first, and this with chilled cast-iron projectiles; but the plate under notice, which was subjected to the same attack as the compound plate, not only withstood the two Palliser chilled-iron shells, simply pulverizing them, in fact, but also stopped and kept out the three Holtzer forged steel projectiles, and this without showing a crack. The plate is the first on record which has succeeded in stopping these forged steel

shells; and it was sufficiently tough to do this without being itself fractured. Still, when the results are compared with those obtained against the compound plate tested on the 24th of March, 1888, it will be seen how the hard face of the latter gives it a marked advantage in resisting the perforation of projectiles.

These results are against direct firing; but against oblique firing the advantages of the compound steel-faced system are far more prominently demonstrated.

The author has treated the subject broadly, and, with the kind assistance of the armor-plate makers, has enunciated the whole aspect of the armor question. He has considered not only what armor is, but how it is employed. It is not a naval question in the first place; it is one of engineering science. It must be remembered that civil and mechanical engineers have originated all improvements in the types of ships, including the introduction of steam, of the screw, of iron and steel in their construction, and of the use of armor. The great improvements in ordnance and torpedo attack are also due to them. The attitude of the engineer towards questions of war material differs from that of a member of a political administration, and from that of naval and military officers. The engineer is mainly interested in the question of the development of the powers of the weapons of war, and he is constantly thinking how they may be extended, and how the maximum of power may be got out of a given expenditure. The tendency with the administration is to estimate the comparative value of available resources of rival governments, and not to look beyond the immediate future. It may be seen from the speech of Sir John Pakington, when introducing navy estimates on the 25th of February, 1859, and when the French ironclad sea-going ships were being built, how easy it is to undervalue new forces. This administration undertook the building and conversion at that time of sixty-seven wooden line-of-battle ships and frigates; and they were all in the hands of the dockyard authorities, in various stages of production, a few months afterwards. But not one of them was suitable for the circumstances of the time. Many of them were never finished.

The author would agree cheerfully to any proposals by the Government, as to the size of the ships and to the use of armor for them, if they were laid for approval before some competent technical committee for a month.

The times are critical, and, if the author were responsible for the

steps which must be taken by the administration, he would insist upon having the soundest independent judgment which could be obtained.

The author's successor at the Admiralty pleaded for inquiry into the subject in *The Times* newspaper in 1884 and 1885. He has himself pleaded privately, but through the proper channels, with each administration in turn from that time to this. The difficulties surrounding the question are not lessening; they are sensibly growing.

The author feels satisfied that if such a body as the Council of this Institution had been consulted in 1868, 1871, and 1875, dates when naval ordnance was in a crisis and under serious debate, it would not have happened that the question of breechloading would have been kept closed from 1866 until 1879. He believes that if such a body had been consulted in 1859, it would have appreciated better the significance of the four ironclad ships then building in France, and the Government proposals would have been wisely modified.

So far as the author knows, the proposals of the Admiralty (which he has not seen) as to large ships and the armor for them may be sound and wise. If they are, it would be very unlikely that such reference as has been suggested could cause inconvenience or delay.

The author is not of those who consider it possible to protect sailing ships and slow steamships by means of cruisers in a severe war. Indeed, nothing has been said in this paper about regular fast war cruisers. Long before he left the Admiralty, and before the design of Sir William Pearce for a fast cruiser was sent in, a cruiser of 22 knots speed, and to hold 2000 tons of fuel, had been designed at the Admiralty; but it was decided not to build it. The views which prevailed were very well stated publicly by Mr. George Rendel, who was then, happily, a member of the Board of Admiralty. He said:

"As far as I understand the question, an alternative is to add to the navy a number of very swift partially armored vessels of war, especially built to act as the guardians of our commercial ships. Now, there are one or two considerations which seem to make that course a very difficult one. In the first place, the number of vessels required would be something enormous. If we make the supreme effort required to provide them, we have to remember that not only would their maintenance be extremely costly, but they would rapidly depreciate in value, from the progress in science. As an example, if we assume that that course had been followed some fifteen years ago,

we should certainly have had vessels engined in a manner which would have rendered necessary a complete refitting of engines and boilers a few years later, because it would be absolutely essential to maintain such vessels at the maximum point of efficiency, and for this purpose compound engines must have been substituted for the engines previously used. Again, another period of a few years, and we should have found ourselves in the presence of the fact that such vessels must be of steel to cope with their rivals of the day. Again a reconstruction of the fleet. On the other hand, if it were possible to make the commercial navy self-protecting, or to a large extent self-protecting, we should be sure always to have, in vessels selected for that purpose, the latest improvements, and to have them at a very trifling cost, because naturally ships would drop out of the list as others of greater power came in. Then, instead of viewing with as much alarm as pride the growth of our great mercantile marine, we should view it with unmixed satisfaction. We should remove the perhaps greatest pre-occupation of those who have to direct our naval policy and naval construction; in short, the object to be obtained is so important that we cannot but think that a very careful examination of the question ought to be made."

But this view does not prevail now. Cruisers of 9000 tons are being built of the same type as the French Tage. And yet those who look ahead can see at least two most important elements of change coming into view.

Look, moreover, at the composition of the squadrons in the manœuvres in 1888. While England had nearly as many 14-knot ships in her mercantile marine as in the Royal Navy, and almost all of them on the Admiralty list as auxiliaries, yet not one of them was engaged.

The Admirals reporting on the operations draw attention to the proved necessity of having an ample supply of swift cruisers attached to a fleet to keep touch with the enemy, and as this had been abundantly proved in 1885, it is difficult to understand why no use was made of them.

The author feels that the difficulty in providing a suitable armament for ships will, for a good many years to come, be even greater than that of procuring ships, and that the merchant auxiliaries will be the last for which provision will be made.

To many minds it seems that the hope of the future, for peaceful sea-traders, lies rather in lessening than increasing the individual

superiority of the special ship of war. They would spare no efforts to raise the character and strength of the fast mercantile ships. But it must be admitted that there is no prospect of a diminution in the use of armor in regular fighting ships. The evident tendency is towards its introduction into every fighting ship.

Recognizing the soundness of judgment of both parties—of those who would improve the regular ship-of-war, and of those who would develop the latent powers of the auxiliary naval forces—there is another question, and to this the author has endeavored chiefly to confine himself.

That question is, Ought England at the present moment to move still farther onward in increasing the size and cost of heavily armored ships requiring four or five years to complete, or ought this country rather to endeavor to increase rapidly the number of protected ships, capable by reason of their speed and armament of taking part in any engagement with an enemy, however powerful? And then there is the further question, Is advantage taken of all the national resources in the manufacture of guns and modern projectiles and explosives, which will certainly be needed much more than ships are needed?

DISCUSSION.

Sir George B. Bruce, president, said he had much pleasure in moving a vote of thanks to Sir Nathaniel Barnaby for his paper on a question so full of interest and importance to the country. However great might be the divergences of opinion upon the question, there could be no difference of opinion as to Sir Nathaniel Barnaby's right to speak on the matter, and there could be no doubt that everything he said was worthy of the most careful and attentive consideration, not only in the Institution, but throughout the country.

Sir Edward James Reed hoped the Institution would not think him obtrusive, as a member of the Council, in taking an early part in what must, he imagined, prove a very elaborate and interesting discussion. He was specially charged to discuss another paper on the following day, and the day after Sir Nathaniel Barnaby would read a very interesting and important paper at another institution. He was afraid therefore that if he did not avail himself of the present opportunity he might not be able to speak to the Institution on the subject. The President had used words with reference to the paper which had been upon his own tongue, namely, that it was a paper of the greatest interest and importance, and, as he had already inti-

mated, he thought it would furnish abundant material for debate, for it not only dealt with the main question in a very broad manner, but with a number of minor questions which were sure to excite great interest. He thought it was due to the author and to the Institution to discuss a question like that with perfect frankness and dispassionateness. He therefore hoped that what he said would be carefully watched for the purpose of ascertaining if he in any way passed beyond fair, legitimate, and real criticism of disputed matter. He wished to guard himself on that point, because he came from another place in which a good deal of heat was generated in connection with the subject. The author had given a series of what were described as "phases" of armor. They consisted of five circles, the first and last wholly shaded. If it were not out of order, he should like to ask the author if he would be kind enough to explain what it was that regulated the proportion of shaded to unshaded area in those circles. He had studied them as well as he could, but he had not been able to see on what principle these diagrams were constructed. They were shaded and partially shaded circles for the purpose, he supposed, of indicating to the eye in a simple manner the relation between the armored and the unarmored portions of a ship. He supposed, therefore, that the shaded part always represented armor, and he might be right in assuming that it represented armor above water; if so, his difficulty was to ascertain what the unshaded portions represented. Were they the areas of the unarmored sides of the ship?

Sir Nathaniel Barnaby explained that his intention was to show the portion of the ship above water which in commencement was completely clothed with armor as represented by the shaded circle. In the second phase some of the armor came off, a part of the fighting batteries of the ship being left uncovered. In the third phase there was still more uncovered; in the fourth phase still more, and then the cycle of changes was suddenly ended by a complete covering again of the side with armor. He thought he had made that point clear.

Sir Edward Reed said that his difficulty was with the diagram of the ship. The area of the unarmored visible sides seemed much larger in proportion to the armored than the unshaded part of the circle indicated. However, the author's explanation would serve all the purposes he had in view. He desired to make a remark about that method of illustrating the state of the armor question. Although he had not the smallest doubt that the author in compiling the paper

had travelled along some clear line of thought, he was entirely at a loss to understand the grouping of the vessels. The circular disks were given to illustrate what might be called the rise and fall and re-rise of the armor. But then this extraordinary thing happened. The author had introduced into the line of progress a couple of cruisers, and they followed apparently in the line with the line-of-battle ships that had gone before them. The author, from considerations which would be present to most minds, and no doubt from a desire to avoid as much as possible controversial points, had selected his illustrations from the French navy, and that had resulted in his introducing into the series of vessels the Dupuy de Lôme. On the previous evening, in the House of Commons, Sir Edward Reed had mentioned that ship; thereupon the First Lord of the Admiralty sprang up and said that if the Dupuy de Lôme system was considered to be of any importance, he was prepared to combat that idea. The vessel, therefore, was knocked out of his mind on that occasion by a very high authority on those subjects; yet he found it in the paper occupying a position illustrative of the progress of the armor question. But if the author had taken illustrations from the British navy instead from the French, it would have been impossible for him to have taken the series of vessels he had chosen, or anything like them, because while it was true that the English were building huge vessels of 9000 tons, resembling the Tage more than any others adduced, it was impossible to put them into one series of ships illustrating the growth or otherwise of armor, because simultaneously with the building of those unarmored ships the Admiralty was about to build eight ships of 15,000 tons, and two others of very considerable size, for which was claimed more perfect protection by armor than had ever before existed. So that, if that series had been taken from the British navy and from the succession of battle-ships as illustrating the progress of the armor question, there would have been, instead of the Tage and the Dupuy de Lôme (vessels covered with 4-inch armor only), the first-class battle-ships now proposed to be built by the Government, and occupying a position of an entirely different character from that which the other vessels could claim. He consequently feared that the outside world (which was a pretty good-sized section) might be seriously misled by the course which the author had taken. He should have expected to find not a mere solitary cruiser of the French navy, and a cruiser so bad that the First Lord of the British Admiralty did not hesitate to denounce it

the moment it was mentioned in Parliament, but such first-class battle-ships as were now proposed. In that case the meeting would have been led from the Warrior down to the first-class line-of-battle ships about to be constructed, instead of from the Gloire to the Tage and the Dupuy de Lôme.

Sir Nathaniel Barnaby said that he had explained that when he wrote the paper he did not know what the Admiralty's propositions were. He knew nothing of the ships in question.

Sir Edward Reed did not think that affected his position, because when the paper was presented the author must have known that the Admiralty intended to continue building armored ships, and ships of a large class. All that he wished to guard against was the supposition that the course of the armor-plate question in this country was in any way represented by the series given in the paper. It was nothing of the kind. If, instead of the 4-inch armor-plate vessels, the ships about to be constructed with very thick armor were taken, the cruisers would be relegated to a very different category and fall under a very different line of thought and discussion. There was nothing in the paper to show that the Tage only came into the series as a cruiser, and that the Dupuy de Lôme followed in that capacity, and that these vessels did not in any way represent the progress and growth of the armor question, as far as he knew, in France, and most assuredly not in England. The paper cleared up what had been mysterious to him for a long time, and it raised a question of the most serious and vital character touching the navy. He had never been able to understand how it was that men of the highest skill and competence in their profession should have produced ships with the extremely limited amount of armor which characterized a great many vessels in the navy. But the explanation was furnished by the author, who stated that, in his judgment, it was of more consequence to be able to inflict damage in war than to be able to resist it. He could quite understand that any one with that idea dominant would indeed sacrifice the material which would permit of resistance, and would devote himself to the development of the attacking force of the ship, which was the chief characteristic of many modern vessels.

That was a principle right enough, he admitted, if a man were fighting a man, or even an army fighting an army, although even then he thought it would be rather bad strategy never to be seeking to use defensive means that were offered, and always trusting to a

superior attack. But in the case of a ship of war the principle seemed to him to be as false as anything could possibly be, and for this reason, that in approaching an enemy on the sea, the latter had with him an ally of the most persistent, ever present, determined character that could possibly be manifested, namely, the sea. If the defense were slighted and the enemy allowed to perforate the ship in such a manner that the sea could enter and dispose of it, the enemy would have the advantage not only of a powerful but of an omnipotent and over-mastering ally, who scoffed at all superiority of attack, giving no recognition to the detailed advantages possessed by a ship, but sending everything belonging to it to the bottom of the sea. That, in his judgment, was the natural consequence of the theory propounded. The paper, as it appeared to him, denied to the country what it had a right to demand. The author had very properly said that the question was no other than an engineering one. He had reproached the sailors with having too little regard for money and consideration of cost. Sir Edward Reed reproached the author with having had a great deal too much consideration for the cost. He thought the country had a right to ask its engineers, in designing a battle-ship for the defense of this island (which was in itself little more than a big ship, although happily not so sinkable as some ships had been made): "Will you send its protectors out into the Channel on a platform which the enemy shall not be able to send to the bottom readily, which he shall not be able to send to the bottom at all by the attack of light and inexpensive guns, and which, when the worst comes to the worst, he shall only be able to send to the bottom by bringing out enormous and costly guns which shall tax his skill and strength to produce?" There was a striking acknowledgment in the paper that in saying that he was not asking the engineer anything that he could not do, because the author not only laid it down that men could be sent into the Channel upon an invulnerable platform, but asserted that everything could be made invulnerable. "There is no difficulty," he said, "except in finding the money, in making an invulnerable ship. Ships can be built and navigated which no torpedo nor ram nor gun which can be worked from any ship now in existence can fatally wound." (He should like to go a little further and say, which no number of torpedoes or rams or guns can fatally wound.) "In such a ship every man may be absolutely protected, high explosives notwithstanding." When a railway engineer was asked to build a bridge across a river he said to his

company, "If you want to bridge the river I will make the bridge, and it will cost you so much"; in like manner why should not the naval engineer say, "If you want a safe ship I can build it, and it will cost you so much." He did not go so far as the above words of the author, to which he knew he did not commit himself; he did not want so much protection as there described, but he wanted the platform protected; he had invariably demanded it, and if a contrary resolution were proposed in the Institution and voted for by every man present, he would nevertheless go on demanding first-class line-of-battle ships so protected that the enemy could not send them to the bottom unless he brought out guns which would severely tax his pocket and his strength to produce. He wanted to know what, as a naval constructor, he had to do with cost. People seemed to think that there was a body which restrained and limited the expenditure upon the navy. That was a delusion. On the contrary, there sat within a few yards of the Institution a body which would sanction any expenditure that a Minister could be got to ask for; and if the House of Commons were told that the Government was going to send men and officers out into the Channel for the defense of the country on invulnerable and unsinkable platforms, there never would be anything more than that which happened now; somebody who thought that the country could do better without any ships at all, or at any rate that it could do with a much fewer number, would make a motion on the subject, but very few indeed would vote for it, and the great majority of the House of Commons—of every House of Commons that he had known, and he had sat in Parliament for fifteen years continuously—would cheerfully grant the money. He saw present a distinguished officer who had been quoted in the paper, Admiral Sir John Hay, Bart., and one of the finest records of his Parliamentary career was his maintenance, from a naval officer's point of view, of the very proposition he was now laying down, that it was not his business to restrain and hamper his profession with questions of money. Nor was it so with the naval architect, and for this good reason, that the thing to be protected, namely, the existence of the independence of the country, was worth protecting at a very considerable cost. Then there was another proposition growing out of that part of the subject which he hoped the meeting would allow him to state. He must express some surprise at it, because he always felt that behind any opinion of the author's there must lie a strong thought of some kind; but he was at a loss to understand

what the author could have behind his words when he pointed out that it was for other countries, rather than for this, to care about a strong individual ship; that this country had not the same reason for desiring to have strong individual ships as other countries. He differed entirely from that proposition. He did not deny that the other part of the author's contention was thoroughly sound and good, namely, that plenty of ships were wanted, and that the power of England should be maintained in a great many parts of the globe. That, he admitted, was a necessity, but it was not the first necessity. The first necessity was the inviolability of England's shores. What was the state of the case as between this and other countries? A seaport town or two might be destroyed in Russia and tribute levied upon them; what did it matter? The effect was hardly felt throughout that empire. Several towns might even be destroyed in France, yet such was the wealth and recuperative power of that country that no mortal blow would be inflicted by anything that could be done to its ports. But in this country nearly all the great towns and cities were ports, or nearly ports, and therefore the first essential to its existence, in a maritime war, was to be able to keep the mastery of the Channel by means of ships individually strong, and as compared with other powers, so to say, omnipotent. And simultaneously with that, a multitude of ships should be secured for the multitudinous services which the navy was called upon to perform all over the kingdom. But, notwithstanding what he had said, he was extremely disposed to go a long way with what seemed to be the main contention of the author, namely, the multiplication of small ships, individually far from weak, for attack or for defense, and of moderate size and cost. The reason was that he could not get the invulnerable ship built; he could not get the safe platform constructed. It seemed to be the determination of every constructor who had power and responsibility, to make it his care not to give to the ship an invulnerable platform which the enemy could not easily dispose of. At the present moment this country was in a position of being about to vote eight millions of money for eight ships which did not to his satisfaction fulfil that primary condition, but were distinctly made in such a way that they could be destroyed without the attacks of the very powerful guns to which he had alluded. Since, therefore, the proper ships were not to be had; since ships costing a million of money were exposed to going down to the bottom of the sea because they had been denied the necessary armor of defense—the necessary height

and depth—he felt persuaded by the paper into the course of preferring the multiplication of ships of less size and cost and taking the chance with them. The vessel proposed by the author was, to his mind, one of an extremely interesting character. Regarding the sea as the enemy's most destructive ally, when once allowed to enter in sufficient quantity, and seeing that the invulnerable platform could not be obtained, the question arose whether, as the ship must be destroyed, it was not better to adopt the author's design. An idea in a vague way had sometimes passed through his own mind whether a vessel should not be produced defended in regard to the engines and boilers by an under-water deck, then filling it up from that deck to a substantial height above water, so that the enemy could not sink it by fire except by the comparatively slow process of blowing out that solid but light material. It was a conception which seemed to him to be extremely full of interest and thoroughly worthy of study and consideration. The thing about it which he did not like (it was a mere matter of detail) was that the author had not in his judgment carried that solid substance up high enough above the load-line. He could not reconcile his mind to vessels which sank when a little water was let into them. He thought they ought at any rate to be able to take some water on board and still float. If there was only a margin of 6 inches, as allowed in the paper, for the solid material above the load water-line, he thought that was not sufficient. This was very much the same question as that of the belt. Why he detested the belt for a line-of-battle ship when narrowed down, as it always was, was this: If the belt was 6 or 8 feet high, or even 4 or 5 feet, a certain quantity of sea could be admitted, or an extra quantity of stores taken on board, and still the vessel would remain a safe, satisfactory, fighting vessel; but if the belt was designed to be 2 feet 6 inches above water, and if it came out, as it often did, only 1 foot 3 inches above water in the finished work, the margin was gone. A desperate effort was going to be made against that in the new ships. He believed the Board of Admiralty had determined to exercise a little direct control over the designing, and the intelligence and knowledge displayed in Parliament encouraged him to believe that many things would be done if it had full scope. One of the instructions to the constructor was, "For the future you must allow a margin of displacement," and he believed that 4 per cent was what had been imposed upon him. That was a very wise thing; but then the constructor, although he had given 4 per cent margin of displacement, had pro-

vided for a very small coal supply; and before the ship was finished he was told to double it, and, when doubled, the margin was all gone. He had no doubt that that was what had been done and was how it happened that a first-class British ironclad, costing a million of money, to defend the interests of the country in the Mediterranean, with 13,000 indicated H. P., was to be allowed 900 tons of coal. There was an odd remark in the paper which he hoped he might be excused for noticing. The author had quoted from Mr. George Rendel, and he had introduced the quotation by stating that Mr. Rendel was then "happily a member of the Board of Admiralty," and, as an illustration of the happy effect which he had on the Board, it was stated that when the author designed a cruiser of 22 knots speed, and to hold 2000 tons of fuel, it was decided not to build it. He did not wish to say anything reflecting upon Mr. Rendel, but if his influence on the Board of Admiralty was to prevent fast cruisers from being built for the British navy, the inference he should draw would be not that it was a happy circumstance that he was on the Board of Admiralty, but that it would have been a much happier one if he had been far away from it. The fact was now acknowledged that the author had been for several years urging the Admiralty to constitute a body to inquire into that great engineering question upon which millions of money were being lavished from the accidental causes of the moment, and the author had mentioned what was perfectly true—that Mr. White, his successor, like himself, had advised independent inquiry. What was the result of it? An expenditure was about to be incurred, not quite so much as some people supposed, but of about sixteen millions, upon ships from the design of one gentleman. He was a thoroughly competent man, and he would always bear the warmest possible testimony to the ability of the present Director of Naval Construction. He was no doubt one of the ablest designers; indeed, the only doubt he had about him was whether he was not a great deal too able. He had lived long enough in the world to be more afraid of very clever people than he was of moderately clever ones. But the situation of things at present was that the late Chief Constructor of the Navy was inviting inquiry, that Sir Edward Reed, a predecessor of his, was urging inquiry, that the present Director of Naval Construction was urging inquiry—that all inquiry was denied, and that the millions were about to be expended upon the designs of a gentleman who was an apprentice when Sir Edward Reed was Chief Constructor, and who, with all his

ability, might possibly be very beneficially restrained by the bringing of other minds independently and freely to bear upon the subject. Millions were to be lavished upon these hole-and-corner designs. He joined with the author most cordially, first, in believing that if the Council of the Institution had been invited to deal with the question from time to time, great public evils and public waste would have been averted, and that if such a body were now called in to advise the government of the country before launching out into such an immense expenditure on designs which he condemned, and which the late Chief Constructor most delicately, but nevertheless most powerfully, called in question, an inquiry might be raised which would save all that expenditure, and which would lead the country, as it ought to be led, by sound, good, broad, professional advice, along that path which ended either in the vindication of its greatness and the preservation of its power, or in overthrow and destruction, under conditions which would terminate its career in an unjustifiable neglect of the known resources of civilization.

Sir Nathaniel Barnaby asked permission to make an explanation concerning the material proposed to be employed as solid raft packing for the defense and stability in small fighting ships. Since the paper had been read, his attention had been called to the fact that specimens of the material had been sent out by the Woodite Company, which, in the conditions in which they were sent, were very far from being non-absorbent of water. He ought to have observed that himself, but he had not done so. The material, as he accepted it, was non-absorbent of water, and he submitted the specimens, which, without any envelop or external waterproofing, were non-absorbent. In order to reduce the price and the weight of the material, the manufacturers had produced what they thought to be a better result. They produced blocks not weighing more than 16 pounds per cubic foot, and they subsequently "waterproofed" those blocks, as shown by the specimens. That latter material when waterproofed weighed, as he had said, about 16 pounds to the cubic foot, and cost £45 per ton. It was impervious to water so long as its jacket remained unbroken. If its jacket was broken, the internal packing admitted water. It did not absorb water into its own structure, and it did not appear to suffer disintegration. The material thus presented two aspects: (1.) A material impervious to water, and weighing less than he gave as a weight which could be accepted. (2.) A material very much lighter when unjacketed, which was pervious to

water, but which was intended to be jacketed and was then watertight.

Vice-Admiral E. H. Howard said it had been stated by the author that he could build four of the vessels described in the paper for one of the monster ironclads designed by the Admiralty, and that he thought was a very important point. Superiority in numbers was a great advantage, giving, as it did, different points of attack. Besides, the four vessels would have four independent heads. The present practice was to make everything dependent on the captain of the ship and to put everything under his control. The responsibility, therefore, of the captain of one of the large ships would be very great indeed. In the case of the four vessels that responsibility would be divided, and for his own part he would much rather have command of the four ships than of the one ship.

Captain C. P. Fitz-Gerald, R. N., said he had the misfortune to be opposed to the author on more than one occasion, but he knew that the author would be the last man to deprecate fair and honest criticism, and he would be able to reply to any observations that were made. He had also had the misfortune to differ from Vice-Admiral Howard with regard to his statement that four weak ships were better than one good one. How he was to command four ships in action he did not know; any captain would probably find it sufficient to command one. If the four ships could be worked under the direction of one brain, there might be some soundness in such strategy, but he held that to be impossible. Signals in the heat of action would be of very little use. The four ships would be governed by different brains, and it would not be possible to bring them all to bear upon the decisive point at the decisive moment. It had been laid down as one of the first principles of war, either on shore or at sea, that there should be the greatest possible force at a given point at a given time. The principle had been a favorite maxim of Napoleon's, and had been followed by all the great captains of all ages. With the suggested division of the responsibility in the four ships, he did not see how that happy conclusion could be arrived at. He was a believer in what had been called the moral effect in war. No doubt the words had been much misused; but still the fact that an army or a fleet thought itself superior either in weapons or in any other way to the enemy it had to fight, was admitted on all hands to be a very important factor in the case. Whether it was a magazine rifle or a breech-loader, or a more powerful ship, it gave confidence

to the men who were going to fight. He knew that it was the fashion to say that the whole business of naval war was being reduced to a matter of mechanical engineering. He ought to speak with caution on the subject before civil engineers, because naturally their minds would be concentrated upon the question of engineering. Naval battles were, in their view, to be fought by machinery, by the turning of a crank, the pulling of a handle, the discharge of a torpedo, or the firing of a gun. He did not believe in that, and he maintained that the personal element—the fighting men themselves—would enter as largely as ever into the question. To go on any other principle would be making a very great mistake. The effort to put the eggs in different baskets was, he believed, a departure from sound principle. The question had been argued from many points of view, and the Spanish Armada had been cited as an instance. The English were said to have had then a larger number of quick-working small ships than the Spaniards, and could therefore buzz around them and attack them as they liked. Professor Laughton, however, had exploded that theory. In a recent lecture he had shown that not only had the English more guns, but heavier ones, than the Spanish, and that they destroyed the enemy by superior seamanship and superior artillery fire, and in other ways into which he need not enter; the English certainly had superior speed and mobility, which was another point of great importance. The author had put forward a ship of 3200 tons, going at a speed of 17 knots an hour. Such a ship might possibly attain that speed, but under what circumstances? In dead smooth water. It was known that a small ship could not keep up its speed like a big ship in rough water. The speed fell off at once, and it was impossible to compare a ship of that kind with one of those magnificent designs of Mr. White's recently brought forward at the Institution of Naval Architects. If a seaman were told that the small ship could keep its speed under the conditions that it was likely to meet with in the ocean, he simply would not believe it. As to the point of tactics, it was all very well to say, "If you bring out your one monster I will attack you with five ships; I have so many more guns and so many more chances than you." It should be remembered that these five ships would get in each other's way and would very likely run into each other. Besides, a battleship did not go out to fight alone; there was usually a fleet, say of half-a dozen ships, and such a fleet would require thirty small ships to attack it. Those thirty small ships could not all be on the same

piece of water at the same time, and could not fulfill the first principle of strategy, that of bringing to bear the greatest force at the decisive moment. The author had quoted a passage from Admiral Touchard, and had thus given it the imprimatur of his authority, expressing sentiments with which Captain Fitz-Gerald could not agree. He also said, "It is difficult to get the sailor to appreciate a money basis. He has to fight in the ships." No doubt it was difficult, and he hoped it would remain so. Naval men did not care about the money; the taxpayer had to provide that. Sailors wanted the best of everything to do the best work; and he believed that the policy of building cheap ships, knowingly inferior to those of foreign nations, was a totally wrong policy. The author said: "He sees that his personal chances of life in the smaller ship are less than they would be in a ship costing four times the money, and he naturally values his life and his chance of personal victory more than he does gold." He did not suppose that the sailor would think much about his life when once he was engaged in fighting, but he did value his chances of victory. It was all very well to put him in an inferior ship and say, "It is true you will be sunk, but it will not matter, because there are others to take your place." That was a false position to place him in, and it was depriving the service of one of the first principles of warfare, namely, that of giving confidence to the men in the ships in which they fought. To endeavor to impress the men with the money value of the ships was a great mistake. The captain, whether of a torpedo-boat or of a line-of-battle ship, carried into battle with him his life, his honor, the honor of his country, of his flag, and of his profession; and he thought that was quite enough, without impressing upon him the fact that his ship cost a million of money. He therefore came to the conclusion that the only policy for England, as a rich nation, was to have the best of everything, and to pay for it. He could quite understand a poor nation building a large number of cheaper ships and trying to multiply its chances in that way; but England had to protect the commerce of an enormous empire, the richest that the world had ever seen, and the envy of other countries, and it was absurd for her to haggle over the price of defending it. Whatever might be the cost, it could bear no reasonable proportion to the riches to be defended, and the only possible way of defending them was by absolute supremacy on the sea, both as to number and as to the individual fighting ships.

Admiral H. Boys said the paper began with a matter of almost

ancient history which he well recollected. The tenor of the author's remarks appeared to be that naval officers in those early days, instead of endeavoring to advance the science of shipbuilding, were rather disposed to check it. It was stated that "the captain of H. M. S. Excellent reported in 1850 that whether iron vessels are of a slight or substantial construction, iron is not a material calculated for ships of war." He well recollected those experiments. They were made by firing at one of the first iron-built ships, at a distance of about 400 yards, with 32-pounders. The material of the ship was called iron, but from the fractures and the débris thrown about the ship, the results were somewhat similar to breaking a pane of glass with stones. He thought the officers who made the trials were quite right in saying that that was not a material that should be used in the construction of war ships, and in doing their best to prevent its use. With regard to the statement that "seventeen iron ships, which had been in process of construction for fighting purposes, were thereupon condemned as useless for war service," he could only say that that was the first time he had heard of it. As to the question of vulnerability of the water-line of ships against artillery: when ships were perfectly steady and in smooth water, perforation under water was almost impracticable, because immediately the shot touched the surface of the water it ricocheted and skimmed above it. In smooth water there was no reason why the water-line should be protected with armor more than any other parts of the ship. With regard to rolling motion, he believed that the rolling "period" of vessels of that description was about ten or twelve rolls per minute; or say one roll in six seconds. Considering that a ship would roll both ways, its dangerous zone would be out of water only half the time, and that would make it three seconds. Then it should be remembered that the attacking ship would be rolling, so that the three seconds would be reduced to one and a half second, which would be all the time that the vulnerable part of the water-line would be exposed to fire. It should also be borne in mind that ships would not be rolling the same way at the same time; if one rolled one way while the other rolled the opposite way, the guns being fixed to the deck could not be pointed to the water-line at all. Then there were two other points to be considered. There was the probability of the swell or wave intervening, as occurred with a ship to which he once happened to belong. A slaver was taken by a ship of which he was gunnery-lieutenant. It had to be destroyed, as it could not be sent

to port. It was a nice "innings" for him to have a day's practice to sink the ship. The slaver was anchored 200 yards from the steam-frigate, both ships rolling from 5° to 10°. The vessel was fired at with 68-pounders and 10-inch guns. He anticipated that it would be possible to sink it at once, but the frigate expended the entire allowance of ammunition without sinking it, after all; it was not possible to get a shot in between wind and water, and it was found necessary to take gunpowder on board and blow the vessel's side out. In olden days, when ships fought under sail, there was the question of weather-gauge. Ships were then always under pressure of sail, and they heeled over; the lee ship had the weatherbends thoroughly exposed to fire from the windward of the numerous guns carried by ships of those days. The guns perhaps could not be aimed as accurately as those of the present day; but considering that there might be fifty or sixty guns peppering away at a ship's weather-side, the chances were that some of the shots would enter below the water-line, and even then the vessel need not necessarily sink immediately. It seemed to be implied that those on board ship had no means of pumping the water out, or taking steps to keep the ship afloat, supposing she should be dangerously wounded. The other point was the personal error of the firer in taking a snap-shot from one rolling ship at another. Altogether, he considered the risk to a ship from the penetration of projectiles at the water-line had been very greatly exaggerated. There was a point referred to at p. 107 of the paper in which he could not agree with the author. "It is not a naval question, in the first place; it is one of engineering science. It must be remembered that civil and mechanical engineers have originated all improvements in the types of ships, including the introduction of steam, of the screw, of iron and steel in their construction, and the use of armor." He would quote only a few lines that appeared a week or two ago in a journal which took another view of the subject. "Science, with her usual pedantic imbecility, has been building ships for some time under the inspiration of algebra and with utter disregard for certain simple practical considerations. The sea, after all, is a very rough road at times, and knocks about whatever goes upon it without mercy." He could not agree that the question was not a naval one. The naval officer was as necessary to the engineer as the engineer was to the naval officer, and the two could not be dissociated. The screw was the invention of a naval officer, Captain Smith; at any rate it was introduced into practical use by him. It

was at the suggestion of naval officers that many of the improvements introduced had been made, and he believed it would continue to be so. The author had stated that he felt satisfied "that if such a body as the Council of this Institution had been consulted in 1868, 1871, and 1875, dates when naval ordnance was in a crisis and under serious debate, it would not have happened that the question of breech-loading would have been kept closed from 1866 until 1879." He would appeal to any naval officer if, during that time, the muzzle-loaded rifled guns were not perfectly efficient. The greatest artillerist of the day, who was one of the brightest ornaments of the Institution, and who did more to reform gunnery than any living man, Lord Armstrong, though he had first instituted the breech-loading gun, reverted to the muzzle-loading gun and made it a serviceable weapon. He did not say that he was at present an advocate for returning to muzzle-loading guns, but at the time he referred to they were certainly the best obtainable, and it was the introduction of slow-burning powder requiring long barrels which could not be loaded inside the ship that had led to the present breech-loading system. The muzzle-loading guns were, on account of strength and simplicity, the most suitable for any naval operation; they were accurate enough, penetrating enough, and rapid enough in firing, and there was at that time very good reason for adhering to them. He differed from Captain Fitz-Gerald as to the tactics of smaller vessels in competing with large ones. The ram of a vessel of 3000 tons, going at 8, 10, or 12 knots an hour, was quite sufficient to destroy the biggest ship that was ever contemplated. As to the class of ship proposed by the author: in action there must be four or five of those ships to compete with one of the larger new ships. With respect to the ram, one was as good as the other. He would, for the sake of illustration, call the large one Goliath, while the four smaller ships might be called Monday, Tuesday, Wednesday, Thursday. By a preconcerted arrangement, and as a point of honor, it should be agreed between the four ships that on whatever day of the week an action might be brought on—if, for instance, on a Monday—the ship called Monday should run any risk in order to hamper the movements of the Goliath, if necessary to get across her bows to be rammed. He maintained that even a 14,000-ton ship, with one of 3000 tons hanging to her stem, must be stopped; then the Goliath would be at the mercy of the other vessels, Tuesday, Wednesday, and Thursday, to ram her on either side. These were

the main arguments in favor of numbers, as proposed by the author, against size.

Mr. W. H. White observed that when Sir Nathaniel Barnaby spoke on such a subject as that under discussion, everything he said must be listened to with respect. When a man had spent forty years of his life almost entirely in endeavoring to strengthen the navy by the addition of efficient ships, and when he had often to keep his mouth shut when anything but fair attacks had been made upon his professional work, clearly when he came forward in public and gave his views upon the past, present, and future, all were bound to attend to him. He was the more careful to say that at first, because nearly all that he was about to say would be in the sense of differing from the author. When the author came forward, it was to be assumed that he came for the purpose of provoking discussion, and of getting as far as possible the opposite points of view clearly stated. First he wished to take strong exceptions to the historical "phases" represented in the diagrams. And he did so for this reason: On reaching the year 1880 there was a change in the type of ship. The Gloire, to begin with, was distinctly a battle-ship; the Marengo in 1869 was still a battle-ship, and so was the Baudin in 1880. After that time the battle-ships were conspicuous by their absence, and they began again. It was not in the same sequence at all. The series began with a cruiser, the Tage, built for a distinctly different service, and the Tage developed into the Dupuy de Lôme, again a cruiser. Of course it might be said that that was merely playing with names, and when ships of 7000 tons were built, to talk of them as not being battle-ships was incorrect. He did not wish to bandy words about it, but he would put the case as it presented itself to him. There was now building in France a battle-ship, the Brennus, and if that vessel had taken the place of the Tage, at the date of 1887–88 there would have been altogether a different condition of things. He of course knew more than he could say about the Brennus, but taking what had been published about the ship, it had a thick-armored belt and strong-armored gun stations, and the question of protection of the side above the thick-armored belt was one which he believed had not yet been definitely decided. That led him to a point which he desired to make most clearly, namely, that in discussing the matter a distinction must be kept between battle-ships and cruisers. He had no doubt that if Captain Fitz-Gerald and other gallant officers found themselves in vessels called cruisers and came across a vessel

called a battle-ship, which, because of size or some difference of construction, they thought they could safely engage, they would do so. But that was not the point. The point was that there were afloat in other navies certain great ships possessing features which could only be attained in ships of large size; other nations had been and were still producing battle-ships, and the question was how could those vessels fairly and with the greatest certainty of success be met on equal terms? He did not say that numbers should not be developed and many cruisers built, but the point he was trying to make was that it was unwise on any mere *à priori* argument, obtained even from the highest source, to be content to rest the defense of all that was most valuable to the empire upon ships which were individually and distinctly inferior to those possessed by other countries. If that principle were admitted as the principle on which the Admiralty policy should proceed, it would be seen that there was room enough in the navy for battle-ships and cruisers, and he wished to point out that in the Admiralty programme which was now before the country, and which included seventy ships, there were only ten that came into the category of battle-ships, eight of them being very large ships, of which so much had been said, and two, vessels of more moderate size. Sixty out of the seventy vessels belonged to the class of cruisers. Nine of them would be large cruisers and approximately the same size as the Tage, but swifter, more heavily armed, and better protected. Thirty-three would probably be vessels of about the same displacement as the design exhibited by the author, and the remainder would consist of smaller swift torpedo gunboats. In view of the almost absolute want of experience in naval warfare under modern conditions, was it not unreasonable that this country should proceed on any merely doctrinaire course, rather than that in the creation of its new modern fleet it should have all classes of ships represented? He would pass by for the present any consideration as to whether the designs were what they should be, the best that could be produced; on that point he would say a word further on. The question was whether as a matter of policy, so much being unknown, it was not the wisest and the best thing to provide against all risks. At the risk of repeating what he had recently said, and in order to complete his remarks, he desired to state in the briefest way what were the principal advantages belonging to increase in size. Captain Fitz-Gerald had referred to one, namely, the maintenance of speed, and of that there could be no

doubt. Then there was a further and very important thing—steadiness of gun platform, of which also there could be no doubt. Then there was the enormous increase in the power of the concentrated attack, which came from having a large armament carried in a single ship under a single direction. Further—and that was the point often overlooked—there was the fact that a large ship was much less likely to be destroyed or put out of action by a single heavy attack, whatever form it might take, than a small ship. It was conceivable that a single heavy shell bursting in the vessel proposed by the author might make it unworkable. Notwithstanding the packing material and the under-water deck, a single heavy shell exploding therein with such explosives as were now known might for all fighting purposes destroy the ship, but with a ship that was very much longer and very much larger, and which had its armament very much more widely distributed, clearly the risk of destruction by a single heavy attack was greatly reduced.

He believed that in fortification the doctrine that he had tried to illustrate took the form of saying that a large place was a good place to defend. He thought that those points for the large ships were clearly points that could not be ignored. Of course they must be paid for. Suppose that four or five ships could be built for the cost of one of the big ones; if what he had put forward was correct, it did not matter whether or not four or five could be built for the price of a large one. If the large one was necessary it must be constructed. What he wanted to present to the meeting was the idea that for the English there was no necessary choice between the two alternatives. It was sometimes put to them as if their finances had run so low that they must multiply small and could not afford big ones. He did not consider that that was the real condition of things. There was room in the navy, with its great range of duties, for all classes of ships, and there might even be room for the class suggested by the author. In criticising the design he was quite sure that the author would take in good part what he was about to say. To his mind there could be no defense whatever for putting a protective deck in a ship of war wholly under water, because, for all practical purposes, the bringing of the deck above water did not sensibly increase the risk of its being directly attacked; but if it was put entirely under water, clearly the space contained below the protective deck in no sense assisted the maintenance of buoyancy and stability, when the upper works were damaged in action; the main-

tenance of these qualities depended chiefly upon wood or woodite packing above the deck. Further, he conceived it to be a doubtful principle, notwithstanding the high authority which recommended it, to put relatively large weights into the form of packing material which added little or nothing to the defense. The woodite, according to the author, weighed from 4 to 5 per cent of the displacement; that must mean about 140 or 150 tons weight put into the woodite for the single purpose of protecting the buoyancy and the stability within moderate angles of inclination. Supposing the protective deck to be elevated, as was now almost universally done, so that it came above the water-line for a considerable portion of the length of the ship, the need for the packing material was reduced without prejudice to the maintenance of buoyancy and stability. Supposing further that the same weight which was put in the packing material was put into coal, there was a defense which, as was well known from experiment, was of enormous value against many forms of attack; the coal was a usable material in the ship, and it might happen that the possession of that additional coal in such a ship would mean the fulfillment of a duty that would otherwise be impossible. His opinion, therefore, taken for whatever it might be worth, was entirely adverse to the adoption of a type of ship which depended for flotation upon packing material which was not in a useable form like coal, and which added but little or nothing to the defense. And it was to be noted that in some foreign navies, where the opposite rule had been adopted a few years ago, a change had been made in the later ships in the direction he had indicated. The author in his paper had not made any allusion to the Admiralty designs, but of course it was impossible to discuss the question without referring to the designs which were now before the public. Sir Edward Reed, in opening the discussion, distinctly did not avoid reference to those designs, and he therefore hoped that he should be in order in making a few remarks on this subject. The objection made to the designs for the large battle-ships had taken this form, that the ships were too large and too costly and had too much armor, according to the author's view, and that according to Sir Edward Reed's view they had not armor enough. Might it be permitted to those who had to do with the designing of these battle-ships to hope that between two such authorities they had struck the golden mean. He spoke simply as representing the Admiralty, which, as was well known, had not proceeded lightly on the course

that had been followed. Never in the history of the navy, as far as he had known it, had there been more careful or even as careful deliberation given to any question. The magnitude of what was contemplated had been fully understood and appreciated, and the country was in a position of knowing what had been done by the papers that had been presented to Parliament. Sir Edward Reed had said, and Mr. White distinctly challenged the assertion, "all inquiry was denied" about the new designs, "and that millions were about to be expended upon the designs of a gentleman who was an apprentice when Sir Edward Reed was Chief Constructor, and who, with all his ability, might possibly be very beneficially restrained from the bringing of other minds independently and freely to bear upon the subject. Millions were to be lavished upon these hole-and-corner designs." "Hole-and-corner designs!" Designs prepared after months of consideration by the Board of Admiralty! Designs which were submitted to and selected by such a meeting of experienced naval officers as had never been before summoned. Designs which he had recently described in public in the presence of Sir Edward Reed, challenging him to justify any of his criticisms on their character. He would leave it to the Institution to judge if such a description as "hole-and-corner designs" applied to a course of proceeding in which the Admiralty had taken the only means of publicity in its power, and had brought to its assistance the best naval advice it could obtain. Perhaps he might be permitted to add one word on the personal reference without offense. He had always thought that it was the privilege of members of the Institution, among whom he had the honor to number himself, that biographical notices should be reserved till they became obituary. Sir Edward Reed had done him the honor to bring to the notice of the Institution the fact that he was once an apprentice. It was perfectly true, and he was delighted to think that it was true. He thought that all who went in for applied science were the better for knowing the use of tools. But he might also add that he was not so young as he once was, although he should never, during Sir Edward Reed's lifetime, be as old as Sir Edward was. With all his rapidity, he could not overtake the start which Sir Edward Reed had attained by the accident of birth. But for twenty-two years he had been continuously engaged in that not very pleasant occupation, designing and building ships, and he thought he might say without egotism that he had had special opportunities of acquiring information, and he hoped in

the public interest that he might prove capable of usefully applying information so gained.

With that remark he would pass away from the personal reference, and simply say that at the Institution of Naval Architects he had dealt with every point of a technical nature which had been raised by Sir Edward Reed; that he had dealt, he thought, to the satisfaction of the members present, with all those points, not as matters of opinion, but as matters of fact. With reference to what Sir Edward Reed had said in regard to coal supply, that given to the new designs was determined by the Board of Admiralty, and was in excess of that of nearly all the battle-ships afloat in the English navy, and greatly in excess of that of nearly all battle-ships of foreign navies. He wished to say one word as to the history of a design in the Admiralty, because he should extremely regret that a matter of public importance should degenerate into anything of a personal nature. The naval members of the board, having before them existing types of ships, desired to embody in some new ship certain features of armor, armament, speed, protection, and coal supply. Those features having been decided upon, it became his business, as the responsible naval architect of the Admiralty, to embody them as best he could in a ship that should be seaworthy, habitable, and capable of attaining the speed and traversing the distances which the Board of Admiralty decided upon as desirable. To speak, therefore, of millions of money being lavished upon his designs, under these circumstances was, he thought, scarcely a complete description of what happened. The designs which had been adopted, it could not be too often repeated, had been most carefully selected by the most experienced officers of the Royal Navy, both at the Admiralty and elsewhere; and, whatever might be their merits or demerits, it was not fair or correct to describe them as emanating from his brain, or to attribute their existence to any initiative of his own. He need say no more about those great ships, except to add that he was certain that even the author, with his recommendation of smaller ships, less costly and less armored, would admit that the addition of those large ships to the navy must greatly increase its force. With regard to cruisers he must again differ from the author, with great respect. When he spoke of the defense of the mercantile marine and appeared to recommend, on the authority of Mr. George Rendel, allowing the mercantile marine to take care of itself, he overlooked the fact that in foreign navies there were great numbers of specially designed

men-of-war cruisers which had to be met by something. He agreed with everything the author had said about the desirability of arming and using the splendid merchant steamers which the country possessed, whenever circumstances of war should arise. It was a perfectly distinct question what these vessels should be used for; how best they could be employed was a matter that would be decided when the time came; but he was convinced that there would be work enough found for the greater number of them without expecting them to take the part of improvised cruisers belonging to the Royal Navy. But if they should be employed, the question to be asked was, were these vessels expected to meet the men-of-war cruisers of foreign navies? Was it to be expected that the very best of those vessels would be capable of staying to fight, on anything like an equal chance, a vessel built specially for the purpose of fighting, a vessel such as the Tage, or the Dupuy de Lôme, or the Cecile? Why had those vessels been developed in the French navy? why had the armored-clad construction of the French navy been almost standing at pause, while money had been spent and every effort urged on to complete such vessels as those? Simply because, as was perfectly well known, it was no breach of official confidence, for it could be read in the French newspapers; the idea which the French authorities had in their mind was to use those vessels, in time of war, to destroy English commerce and the mercantile marine. How were they to be met, if in the English navy there were not to be found vessels equally fit to fight and certain to overpower the French vessels, if they met them? How was that to be done unless the English also constructed large and swift cruisers powerfully armed? The author had referred to the fact that cruisers of 9000 tons were being built for the Royal Navy. He thought the country had good reason to rejoice that that was the fact. The vessels now being built, the Blake and the Blenheim, if they fulfilled the intentions of the design, would be superior in coal endurance and in fighting qualities to any vessel existing in the French navy, and surely such a fact as that was one which justified their existence. Then, as to their being so large, he could not help saying that he thought the author knew why they had become so large, why the Blake was a vessel of 9000 tons, because it steamed 22 knots an hour and had a weight exceeding 1800 tons assigned to coal and disposable weight, independently of armament and equipment. The load of protection, armament, equipment, and coal closely approached

4000 tons. If the Admiralty were content to give up speed, if it were content to let vessels that were being built abroad run the chance of being met by a vessel that could not catch them, then it could reduce size and save money; not a saving to the country on the whole, perhaps, but a saving in one direction. Passing from those somewhat controversial matters, he would refer to a subject which was strictly germane to the paper, and in which he happened to have a special interest, and certainly some special information; he referred to the subject of the manufacture of armor and to what had been lately done in this country in the development both of steel-faced armor and steel armor. Nearly three years ago he was informed in the public press that he was an obstructive. That was not the first time, but it then happened that he was again declared to be an obstructive. The subject was armor, and he was obstructive because he was said to be still recommending to the Admiralty the continued use of steel-faced armor, and was blindly shutting his eyes to the magnificent results which were being produced at Creusot. Safety was only to be had by giving orders for armor to the establishment at Creusot. English steel-makers had been left behind, and the French were head and shoulders above them. But he believed that if the English steel-makers were given a chance they would prove that their hands had not lost their cunning, and that in England armor could be produced, whatever it might be made of, that should be as good as any made abroad. He was glad to say that the view he then put forward was approved by the Admiralty, with the result that a series of experiments had been undertaken that had been in progress for more than two years, and had proved that England could produce steel armor as good as any produced abroad—he believed better—and steel-faced armor, which was one of the grandest defenses a ship could have. The author had alluded to those experiments, and particularly to the experiments made against the armor-plates supplied by firms at Sheffield whose reputation had been made in that branch of manufacture, firms which had done good work for the navy, and had given as honest and true a defense as was possessed by any war-ships afloat. The Admiralty had not only obtained from Messrs. Cammell and Messrs. Brown splendid specimens of steel-faced armor to be used as standards, but those very firms had made steel armor of great excellence; and firms like Messrs. Vickers had produced steel armor in many respects of a marvellous quality. This showed clearly that

if the need arose for re-enforcing the possibilities of the recognized armor-plate Sheffield firms, the necessary resources were to be found in this country without going abroad. The question was not any longer one as between steel-faced and steel armor. Steel-faced armor in the trials had behaved magnificently. The trials had justified their practice up to date, and it was now known that steel armor as well as steel-faced armor could be used and the most splendid results obtained. Those plates had been fired at with projectiles made in France, and he did not know why, if the defense could be so satisfactorily accomplished, English firms should not also make the means of attack.

Sir Frederick Abel said it might seem to be the climax of presumption for a chemist to take part in such a discussion, but perhaps there might be some little appropriateness in the remarks of the Chief Constructor of Her Majesty's ships being followed by some observations from one who had taken some considerable part in developing agents for the destruction of ships, and it was from that point of view only that he desired to say a few words, some of which would be words of friendly criticism. With reference to the point in which he took the most interest, namely, the effect of shells against armor-clad ships, he confessed he came to the conclusion that a naval man, in reading the paper, must be somewhat puzzled as to what he was to expect from the effects of the so-called high explosives against those ships. The author had stated (p. 9) that after the Italians had made some experiments with gun-cotton shells, "English artillerists were endeavoring to perfect a delayed-action fuze so as to delay the bursting of the shell containing high explosives until after the armor had been perforated. Since then every government appears to have had experience, at the proof butts, of the difficulty of making a trustworthy controllable fuze for this purpose." He then went on to say, "When this fuze has been established, shells charged with high explosives will come under control, because bellite and lyddite appear to be in themselves manageable." He further stated that "the French authorities have satisfied themselves that they have brought melinite under control. The introduction of 4-inch side armor over the batteries proves this." In looking for the proof, he found it stated further on that "it has been ascertained that a delayed-action fuze is not at present procurable, and that the shock caused by 4-inch armor will explode shells with high explosives, fired from moderate-sized guns, on striking." Then it was stated (p. 11) that

"Experiments have hitherto indicated the certainty that armor will be blown in by charges exploded against it, and that bursting charges with high explosives will be carried through armor probably 12 or 14 inches thick." Those statements appear to me to be hardly reconcileable, and he should be glad to hear what the author had to bring forward in the way of facts as to how they could be reconciled. He might state it as a fact, however, that delayed-action fuzes were no longer a matter of theory—they had been actually developed. More than one thoroughly reliable delayed-action fuze was now attainable; and if the effective application of high explosives depended only upon the provision of a thoroughly reliable fuze of that nature, the naval officer might depend upon having, in the next war, high explosives brought with perfect efficiency to bear even against thick armor. But it was known, on the other hand, that the provision of such a fuze was not the only element in the successful application of high explosives to the destruction or penetration of armor-clad ships. The author had pointed out that 4-inch plates would cause the explosion of high explosives when thrown against a ship in the form of armor-piercing projectiles. It was true that he stated in another place that they would be carried through 13 or 14 inches of armor; but, as a matter of fact, it had been shown that 4 inches of armor could cause the explosion of armor-piercing shells containing high explosives. He would venture, however, to caution constructors as well as naval officers against drawing too rash a conclusion from that fact. It had been already proved by experiments that 4 inches of armor would not always keep out high explosives; that such armor could be penetrated by armor-piercing projectiles which would carry the explosive charge through. Not only that, but still further progress had been made, and similar results were now obtained against 6-inch armor. Chemists were only on the threshold of the application of high explosives, and he ventured to think, therefore, that it would be necessary to exercise very considerable caution before laying down the rule that armor even exceeding 6 inches in thickness, whether steel-faced or steel, would of a certainty keep out high explosive shells.

Captain Orde Browne said, a fact on which it had been very difficult to get information had been now stated, namely, that shells charged with high explosives might penetrate 6 inches of iron, and that it was desirable that vessels should be divided into two classes, battle-ships and cruisers. Did not the question consequently arise whether

armor ought not to be treated in two different ways? A cruiser carried armor that might allow a high explosive to pass into the interior much more easily than a battle-ship, for it might probably be a long time before a high explosive could be got which would pass through 18 inches of armor such as the battle-ship carried. The cruiser, as he understood, was intended to carry on a fight only for a short time. He did not suppose it would be expected to engage a land fort, for example, under ordinary circumstances. There were cases in which a line-of-battle ship might have to do that. He believed the author considered this to be a total misuse of ships, but such things would sometimes happen. If distinction were made between the two classes, did it not follow that a harder class of armor should be provided for the weaker ship in order to make sure that it should keep out or break up shell with a high explosive under any circumstances? The first object with the cruiser was to be sure to preserve it from a shell with a high explosive entering inside and then bursting; and he believed that was to be done by hard armor, at the expense, no doubt, of what had never before been allowed in this country, namely, the plate breaking and being held up to a certain extent by bolts behind. He had heard Mr. Vickers speaking of the two plates he had submitted for trial, one harder and the other softer, and saying that he did not know which was best. The question was, what for? If the plate had such a thickness that without doubt it would stop perforation, and that impact of shells was expected to happen again and again, then, of course, the softer the better. If a weak ship was to be exposed a short time, the great object was to make certain that no high explosive should get into the interior. Was it not worth while to allow armor to break to pieces if it were thereby made certain that it would keep high explosives out? In this country it had been continually insisted that the back of the armor should be soft, because unless it was soft, whatever theoretical power of extension as well as tenacity it had, it would not extend but would break. The Admiralty had insisted upon its extending as much as possible and upon its breaking as little as possible at the back, and the result had been that the plates had necessarily been soft at the back. He was therefore anxious that experiments should be made with a harder class of armor, with a view to those thinner clad vessels which were now found to be open to the entrance of shells charged with high explosives.

Mr. B. Martell said he merely rose to ask a question. The author

had made a statement (p. 19) which he thought, unless some further explanation were given, might be misleading. "The most successful plate," he said, "ever fired at in England or elsewhere, so far as the author can learn, is shown in Figs. 5 and 6. It is a steel-faced plate, 10½ inches thick, manufactured according to their process by Charles Cammell & Co., and attacked by 6-inch forged steel shot of 100 pounds weight, and having a muzzle velocity of 1976 feet per second and a striking energy of 2723 foot-tons. Mr. Wilson says "it is the first steel plate which has ever withstood such a severe test without breaking up, and that certainly it has proved much superior to any plate manufactured at Creusot which has been subjected to artillery fire." Seeing that the subject was of national importance, and that manufacturers had been devoting their enterprise and investing an enormous amount of money in perfecting the best steel armor-plates that could be produced, it was greatly to be regretted that the author had not mentioned all the experiments, referred to by Mr. White, that had been made by the Admiralty with plates manufactured by the various firms throughout the country. The plates manufactured by one steel manufacturer alone had been expatiated upon, while those produced by other manufacturers for the same purposes were not even referred to. Considering the high position occupied by the author, it might almost be considered an act of injustice to those who had competed, to find that no allusion had been made to their plates. He had seen official reports of the experiments, and he should like to ask whether the author had seen any official report bearing on the subject, so as to be sure of the accuracy of his statements. In one of the reports allusion was made to a steel plate that had been experimented upon at the same time. Five shots had been fired at a 10½-inch plate by the French shells to which Mr. White had referred. He shared Mr. White's surprise that the French should have been called upon to make shells to fire at English armor-plates. Two of the five shells were cast-iron, and they crumbled into pieces on striking the armor-plate; the other three, which were steel, made an indentation to a certain extent, but, to show the tenacity and the resistance of the armor-plate, they rebounded so that they struck the shot-guard some 20 feet distance, and rebounded back again to the steel armor-plate. He wanted to know why it was that no information had been given by the author on that subject.

Mr. W. H. White said that the question was not one which the

author could answer. The facts were simply these: The Admiralty, in entering upon the experiments, gave to each firm that submitted a plate the guarantee that it should be fired at under the same conditions, and that the firm should have the report on its own plate. Although Mr. Martell was no doubt accurate in his statement that he had seen a copy of one report, that would be owing to the action of the particular firm in question.

Mr. B. Martell hoped the author would use his influence to obtain a copy of the official report for the good of the country, in order that a proper comparison might be made of the experiments. When the manufacturers of the country were incurring such an enormous expense and striving so much to arrive at the perfection of armor-plating, everything should be done to encourage them, and at least put them on a fair footing with each other. When such statements were made as those put forward by the late Director of Naval Construction, they would have an enormous effect throughout the country, and would not, it was thought, appear fair to those who had entered into the competition.

Mr. E. Robbins said he had come to the conclusion that in order to meet all requirements a new departure was essential. Instead of steel plates, he had formed the idea of having interwoven bands held on not so much by rivets as by an elastic binding concrete. The bands would be combined with wood and metal, and would form an elastic body which would throw off shot.

Admiral J. H. Selwyn remarked that the paper appeared to touch almost every question known to naval architects and engineers who occupied themselves with ships or guns. He would not refer to all the points, but would only mention six in which he thought they were still behind in scientific work. There had been an enormous amount of rule-of-thumb work, which consisted in a system of trial and error on the large scale, and sufficient attention had not been paid to the scientific basis of action. It was now generally agreed that long-continued speed was an absolute necessity for all ships, and in order to get that (even more valuable for cruisers than for battle-ships), strong boilers were wanted. But were the boilers strong? An advance had been made during the last five or six years in compound engines, though, unfortunately, ship-owners had been persuaded that the essence of the whole was in the engine and not in the pressure on the boiler. He had known a high-pressure boiler, one of the much-abused boilers of the Wanderer, on Mr. Perkins'

principle, which had since been at work for eight years, day and night, at 350 pounds pressure, which was tested at 2000 pounds on the square inch when made, and which was to-day capable of taking 500 pounds pressure without injury. He considered that no proper boilers would be constructed as long as that part of the subject was not closely investigated. Without those high-pressure boilers, neither a high economy nor a high speed could be attained. That high speed, to be of value, should not be produced by a puff of forced draught; it should be produced over a long time. To get that, the use of concentrated or fluid fuel was wanted. He had been long at work on that subject. He was delighted to see some progress in armor, but it had only proceeded from solid steel and solid iron to sandwiched steel and sandwiched iron; it had not proceeded on a well-defined scientific basis. He was glad the author saw his way, if only money enough was given, to produce vessels which could not be sunk by shot, torpedo, or ram. Sir Edward Reed asked the question whether it could be done with many torpedoes, many guns, and many rams; and he did not think that that question had yet been answered. The nearest approach to it would be when the whole power of the engine could be devoted as well to pumping out the ship as to propulsion. Strong and far-reaching guns were also wanted. He had made it his business to look into the subject of wire guns, and a question had been asked in Parliament on the subject. Engineers, he thought, would be surprised to hear that so long ago as 1884 the Ordnance Select Committee recommended a riband-gun as having demonstrated completely the durability and the reliability of the wire system for very high pressures; the guns having been made, not by Mr. Longridge, but by other persons, after they had found out that the rule-of-thumb was of no good, and that his formulas were valuable. A wire gun at Woolwich fired a shot 12½ miles without any injury, at an angle of 40°, and with a charge which was nearly double that which the 9-inch gun of the same caliber, a service gun, could possibly have stood. Why that gun had not been brought forward he did not know. He believed that the system of wire-gun making would be brought forward some day as a commercial manufacture, on account of its extraordinary cheapness and durability. No proper result would be obtained from strong guns without strong powder. So long as cubes of powder were used, many of which would not burn even after they got to the muzzle, and at night were seen burning afterwards, which also tended more to erode the gun

than any gas, so long scientific principles would not be brought to bear on the question. With regard to the six points to which he had referred, everything that was desired could be done in respect to number one by Perkins' boilers; to number two, by concentrated fuel; to number three, by a scientific construction of armor; to number four, by hydraulic propulsion; to number five, by wire-guns, and to number six, by perfect combustion, as Colonel Brackenbury had called it, of "the spirit of artillery, or good, strong powder."

With reference to the subject of armor-plating, the author had stated that Mr. Alexander Wilson was the inventor of compound armor. In 1870, Admiral Selwyn first drew the attention of naval architects to the construction of armor on the analogy of the anvil. He did not know whether sandwiched armor might or might not have been invented before, but sandwiched armor never could do what properly constructed armor would do. He was not ambitious of claiming priority of invention in compound armor as now made, but he maintained that a most important investigation was now possible, based on experiments which had given a cone of dispersion that had sufficed to spread the impact of perhaps 9 or 10 inches diameter over a diameter of 48 inches, making a bulge at the back of the plate of 2 inches deep, which had crushed up the oak behind it, but so spread the number of tons force received on the point of impact over a larger area of 48 inches in diameter, instead of 9 inches, or as 63.6 to 1809.6 square inches, as to bring it down to not much more than 7 tons on the square inch on the oak backing of the armor. That was a magnificent result; but the plate cracked in consequence of its not being properly proportioned, and what he urged on the engineers was the question whether the most important molecular movement of the steel particles was not more valuable than any great thickness of steel face or wrought-iron backing. The plates now made by Sir John Brown were, according to the Ordnance Select Committee, a little different from what the author had described, being made by wedging, 4½ inches from the back of a 16-inch plate, a steel face supported partly round three sides, and pouring the cast metal in between the two from above. That cast metal had been brought to such a heat that it united both with the steel face and with the wrought-iron back, and the result on its being fired at with a Holtzer or Firminy armor-piercing shot was such a cone of dispersion as he had mentioned; and which ought to show one of two things—either the steel particles had separated from each

other entirely in their descent through an average of 2 inches over 48 inches of diameter, or they were in perfect cohesion. In one case, the steel could be no longer steel, but powder; and in the other it would be evident that the great molecular movement could take place amongst the steel particles without disruption, and a great absorption of force, or "shot work," in that manner be obtained, making it possible to have much stronger armor with much less weight, and probably at considerably less expense.

Admiral Sir George Elliot was a supporter of the views of the author to a large extent. He did not propose to dilate on the subject of the papers that had been written, but would content himself with offering a few remarks, from a tactical point of view, with regard to the character of this new design. He considered it a most valuable novelty in the designs of ships of war, and one upon which the efficiency of the future fleet of the country, and indeed the safety of the empire, depended. He looked upon the question of a battle-ship solely from the point of view of a great fleet action. If any attempts were made to depart from that view and it was endeavored to give a battle-ship other qualities, its fighting efficiency would be to a certain extent lost, and the battle would be therefore hazarded when it arrived. The object should be to gain victory. The fate of the empire would probably depend upon the result of some great fleet action, and not upon fights between squadrons. Decisive battles would be fought, not between two different powers, one of which was striving to run away, but between two powers that had come out on purpose to fight. That had always been the case, and it ever would be. So far, therefore, he differed from the author, although he quite understood that he had been pressed into giving his ship the speed he had given. A battle-ship did not require a 17-knot speed, a 14-knot speed was ample; it would give a certainty of a 10-knot speed in battle. That was all that was required, and all speed given beyond that was so much loss in fighting power, and so much risk of losing the battle when it took place. The new 14,000-ton ships were designed for 17- or 18-knot speed, but if they were built for 14-knot speed they would have a far greater armor protection, and far greater safety and efficiency in battle. It was said that great speed was required in case the enemy, when sighted, should try to run away. In olden times, when an enemy was sighted, the frigates were let loose like greyhounds, to attack the rearmost ships of the fleet and bring on an action, and owing to many causes there would always be sluggish ships in every steam fleet.

Nowadays cruisers should be made as swift and powerful as possible, and he, for one, should not object to see the first-class cruiser with 14,000 tons displacement, because battles between single ships or small squadrons would always be fights in which the gun would predominate, and in which the ship could escape from the ram and torpedo. The author had spoken of unarmored ships being combined with a battle-fleet, and therefore having to run the same risks as the battle-ships. He denied that altogether. The cruisers that would be attached to the fleet would form a separate squadron, like frigates of old, and would be kept out of action until the opportunity occurred for their coming and rendering assistance probably to the crippled ships of their own country; but they would not be placed in the line of battle. It was impossible to go into this question, which was a very large one, as fully as it ought to be dealt with without trespassing too far on the patience of the meeting, and he would confine his remarks to those which he could, perhaps, best offer as a tactician. The whole question was whether the gun power was to be concentrated in one vessel or divided between a number of vessels, thereby multiplying the units of a fleet and reducing the risk of great disaster. He was not prepared to say that he would now hold to the size of the ship that had been brought forward; but, taking the ship altogether, he thought the author had done everything in his power for a ship of that size. For himself he should be inclined, for reasons that he would state, to advocate a vessel of twice the displacement as the limit of the size of the battle-ship of the future. In that way he would have two ships of 7000 or 9000 tons for one that the Admiralty was going to build of 14,000 tons. That would enable him to make the protective deck sufficiently thick to ensure safety to the magazines and boilers. The vessel should be of deep draught in order that the armored deck should be as horizontal as possible. If the vessel was of shallow draught, height being required for the engines, a turtle-deck became necessary, thus making it more easily penetrable by shell. He should like to see a 6-inch deck horizontal, which would prevent the penetration of any shot from any gun that was carried. The great fault that he had to find with the Admiralty design was the want of recognition of the destructive effects in a fleet action of the ram and torpedo. He believed that in the first great battle at sea more ships would be destroyed by the ram and the torpedo than by the gun. It had been so customary to look to the gun as the ruling power that that

idea was not readily given up; but he thought that when officers were called upon to report upon the nature of the battle likely to be fought, they should have before them a plan of campaign, and also come to some decision as to the character of the fighting of the future. On these points he did not think that any settled plan had been determined. The whole thing depended upon the future mode of fighting. Was it to be as formerly in line of battle, in close order in one, two, or three lines? If that was the case, he could only say that the prospects of destruction from the ram and the torpedo were far greater than could be expected from the gun. Taking into consideration the number of ships that would be brought together in close contact, it appeared to him to be impossible that they could escape the torpedo. It was said that the torpedo was erratic and did not go straight. Torpedoes, however, would be cruising about in the middle of the fleet in one direction or another. It was said that they might hit the friend as well as the foe, but still the danger existed. There would, he imagined, be two torpedo gunboats attached to every battle-ship that went into action, besides the torpedoes which the ship carried, and he did not see how it would be possible to escape them. The ship might not be sunk, but one blow would open a compartment and let in sufficient quantity of water to put it out of trim, and then, being disabled, it would be at the mercy of the nearest opponent. The Admiralty had not recognized the destructive effect of the ram. The best proof of that was that the bows of all the ships were unarmored. The bow of every French ship was armored. If two fleets met, and one had stronger bows than the other, the ships with the strongest bows would have the advantage. They might not strike end on, but they would hit the bow somewhere, and the strongest would come off best. The shorter and the handier ship would have the opportunity of planting its spur on the bow of the other. If there was the smallest oblique angle of the ram on the bow, there was at once an advantage; the handier ship would have that advantage, and that point had not been sufficiently recognized. It was stated that the Russians were going to build enormous armor-clads; he only hoped they would do so. He did not know what their size was to be, but his belief was that other nations would try and multiply their torpedo-boats and their smaller vessels, and trust more in the future to the ram and torpedo than to the gun. In his opinion the days were gone by for big ships, big guns, and side armor. He held that opinion twenty

years ago and had not altered it. It was said that officers in the future would not have the pluck to ram. History did not record that French officers were wanting in pluck, and he believed what an old and distinguished officer had said to him, that the great work in future in naval battles would be ramming. If so, the proposed monster ships would be a decided mistake; the bigger the ship, the more easily it would be rammed, and the same blow would disable a big ship as would disable a smaller one. When it was said that the smaller vessels would be destroyed in detail, it was forgotten that those smaller vessels would all the time be endeavoring to undermine those enormous citadels with whom they were opposed. With regard to the raft body, he believed, as the side armor was penetrable, that this mode of protection would be far the safest, as a ship would have to be very much riddled before water enough would be let in to disable it; but let one shell or shot go through the armor into a large compartment, or reach the magazine or boilers, and the vessel would be at once totally disabled. He would only add that every ship intended to ram should be armor-clad round the bow, with struts across so as to support the armor. In that case the vessel, if it rammed another, would not, as had hitherto been the case, do itself as much injury as the vessel it struck.

Mr. T. Nordenfelt said he thought the author was quite right in laying stress upon the cost of ships of war, because if the nation could afford to build very large and powerful ships very heavily armed with heavy guns, and could send them out to fight the sea-battles referred to by Admiral Sir George Elliot, it would be able to hold its own on the seas, and would have a distinct and decided advantage over powers who could not afford it. He thought a fleet of eight 14,000-ton ships was a grand and admirable thing. It might be expensive, but it might carry the day in battle. Some of them might be lost, but the others might gain the victory. Mr. White had very carefully and cautiously said that such vessels as had been recommended by the author might even find room in the British navy. Those words "might even," however, did not apply to foreign nations. When they had adopted it, perhaps the British might follow suit. With many foreign nations it was a necessity that the ship should be able to carry heavy guns. Some of them could not afford to build heavy armed ships. England, besides the grand nucleus of 14,000-ton ships, required also a large number of ships which could carry heavy guns for the purpose of the very

many points of defense that were necessary. Even England, however, could not afford to have 14,000-ton ships at all the out-stations, coal-stations, and depots; but needed guns powerful enough to penetrate other ships that might be met with at those stations. About ten years ago he remembered that a smile spread over the faces of some of the authorities at the Admiralty when the Italians commenced their eight large ships, beginning with the Duilio and ending with the Umberto; but even to-day those ships would give them the chance of doing enormous damage at sea, and they might live somewhat longer than their opponents. The word "battle-ship" was, he thought, somewhat limited in the meaning set upon it by naval men. It was nowadays difficult to know what a battle-ship meant. The new cruisers of the Mersey class, carrying 9.2-inch guns, 22 tons, had to do battle for their country like every other ship, and they would no doubt join in a big battle; indeed they could not be kept out of it. Most of the smaller cruisers had no protection except the steel deck against vertical fire or against the explosion of shells. The great object of the paper, as he understood it, was to advocate a ship something between the cruiser, so called, with a steel deck, and an armored ship. He had made a ship which protected the guns, the gunners and officers, the machinery and all the vital parts. Mr. Nordenfelt's view of it was that it was a gun-carriage—a means of supporting and carrying the guns swiftly enough to overtake large ironclads, even if not swiftly enough to escape cruisers. But it was not wanted to escape cruisers; they had big guns and armored turrets, and the object was to catch them; and he thought that a speed of 17 knots an hour was perfectly sufficient for what he might call a mobile gun-carriage. The author had said that such ships could meet an ironclad if they were four to one. If there were four ships carrying 9-inch guns or other guns, and if they could, from being handy, choose their position of attack against the big ship, even if one or two of the smaller ships were lost, the big ship would probably be disabled before the other smaller ships were lost. It had lately been proposed by a foreign nation to have ships of the type recommended by the author with 6-inch quick-firing guns, two on each ship in action at the same time, and all capable of an all-around fire. With four ships capable of more speed than the big ironclad to be attacked, each ship having always two quick-firing guns in action, that meant a firing power of from fifty to seventy shots per minute, each shot being a 100-pound shell containing a

high explosive, thus giving from 2 to 3 tons of shell metal fired during each minute against the ironclad. What would an ironclad with a very large percentage of its surface unprotected look like in a few minutes after such an attack? It could only fire with its big guns one shot every two or three minutes in addition to the fire from the auxiliary armament. He would rather fight on board one of the smaller vessels than on the big one. Time was a very important element in work of that kind. He had had the honor of being the first man to introduce into this country officially the system of quick-firing guns, and had in fact given them the name "quick-firing guns," and he believed that such guns had to a great extent revolutionized naval construction. But it was easy to go too far and to put too much weight in armor. Sir Frederick Abel had spoken with reserve about high explosives, but Mr. Nordenfelt thought that Sir Frederick could have told the meeting that it was a fallacy to suppose that any plates of 4 inches must necessarily cause on the outside an explosion of high explosives. If a high-explosive shell could not to-day penetrate 4-inch or 5-inch plates, it would do so to-morrow, and long before the ships were ready. Field artillery, cavalry, and infantry attacked the enemy without any protection whatever, because if they had protection they would lose their mobility. And it was the same at sea. Fortifications, temporary and fixed, were wanted ashore. Big ironclads were needed, no doubt, in the same way for resisting the fire of the enemy. But there was room also for other ships, and he was perfectly certain that gallant sailors would prefer to feel that they were on board a floating gun-carriage which gave them an enormous power of attack, rather than be in another kind of carriage in which the defense was more studied than the attack, and in which they had to be protected by thick armor for a time. No protection was perfect. If a shell hit a big ironclad when it happened to heel over so as to admit the shell below the armor, it would be most seriously injured, and a ram or a torpedo might sink it. The protection could not be perfect, and he therefore preferred the means of powerful attack to the means of protection. He wished to say one word on the subject of armor plates. Captain Orde Browne had said that it was understood to be necessary for the armor plate that it should have a part of it, the hinder part, which would hold together the pieces in front when the front pieces resisted the attack of the shells. No doubt that was so at the time. Mr. Alexander Wilson did a great deal of good by his patent for compound armor

in days when there was a want of experience in steel-making. The solid steel plates made at the Creusot Works by Mr. Martell and by others were very brittle, flew to pieces, and laid bare the side of the ship, and Messrs. Cammell and Messrs. Brown had benefited the various navies during the last decennium in enabling them to use armor of which the front part resisted shells, the hind part welding the pieces together. If steel-makers had succeeded in making solid steel plates of such a quality that they not only resisted the shells sufficiently but were able to hang together, surely that was better and safer than the older plates. He admitted that compound plates could be made harder at the surface, and consequently tend to break up the shells, but shells were now made that did not break up even when fired at a sharp angle. What was wanted was the thickness of solid steel with sufficient percentage of carbon to resist penetration. Some remarkable results were exhibited in the photographs of plates made by Mr. Vickers. If such solid steel plates could be made in large quantities, they would be more useful than the plates which had not so complete a resistance. He liked formerly a hard steel face even if it were shattered in breaking up the shell, because it was not likely that two shots would hit in the same place. But still better than that was a plate which did not let the shot pass through and which did not fall off when struck. Admiral Howard had spoken of the advantage of small ships in comparison with large ironclads, and he had mentioned one point that could not be too much dwelt upon, namely, that there were four brains and four captains to take charge of the same power or the same money that was placed under the charge of one man in a larger ship. Another officer had spoken about splitting the brains into four, but that was not the point. The point was the question whether the power of the single brain could deal with the responsibility and the many complicated questions that continually arose when commanding a ship of war, or whether the intelligence and experience of four captains of ships would not be preferable.

Mr. T. E. Vickers wished to refer to the question of the material of which armor plates should be made. He submitted for inspection photographs of two solid steel plates which had been tried in the recent series of experiments made by the Admiralty and alluded to in the paper. The plates were all 8 feet by 6 feet by 10½ inches thick, and were tested on board H. M. S. Nettle, at Portsmouth. The gun used was a 6-inch gun charged with 48 pounds of powder and 100-

pound projectile. The plates were supported in a framework against wood backing, which represented the side of a ship. The gun was placed at a distance of 30 feet from the plate. Photographs were taken before being fired at and after each shot was fired, and any fine cracks were marked with chalk so as to be seen plainly on the photographs. Afterwards, the back of the plate and the wood backing were photographed in order to show to what extent the plate had answered its purpose in protecting the ship. The steel projectiles were also photographed. Five rounds were fired at each plate; the projectiles used for the first, second, and fifth rounds were the well-known Holtzer steel armor-piercing shells; at the third and fourth rounds ordinary Palliser chilled-iron shots were used. The first of the two plates was delivered to the Government before the steel plate of Messrs. Cammell mentioned in the paper, but was tested after it. The three Holtzer shots, after penetrating the plate to a considerable depth, rebounded against the bulkhead through which the muzzle of the gun protruded, and the Palliser shots were broken into small pieces. The throwing back of the steel shots was unprecedented, as far as English experiments were concerned. The second plate was made at a later date in order to see if the good results at the first trial could be repeated. Advantage was taken of this second trial to try if a somewhat harder plate would give a better result. This plate was penetrated to less depth than the preceding one, and the Holtzer shots were thrown back with greater force and were also broken; the plate itself was rather more cracked than the first one, but not seriously so. The whole of the plate remained in position, although one corner was found separated when the plate was removed. The second plate was fired at on a frosty day, and it was possible, if not probable, that the increased cracking was due to the lower temperature. The conclusion he derived from these experiments was that the hard nature of the steel which could be used in the front portion of the compound plate gave a better resistance to the projectiles than the first portion of the steel one did, but that this advantage was lost by the comparatively feeble resistance of the iron portion behind it. The steel plate continued its resistance to the last, as shown by the fact that the steel projectiles rebounded with considerable energy. He believed that in thicker plates the advantages of steel would be still more marked.

Mr. Sydney W. Barnaby said he proposed to address his remarks not to armor, but to that part of the paper which was to him of greater

interest, namely, the new material introduced by the author as a substitute for armor at the region of the water-line. It was astonishing to learn that with an appropriation of 5 per cent of the displacement of a vessel, a solid belt of that material could be placed at the water-line, which would exclude 96 per cent of the water that would otherwise enter through perforations at that region. The author had shown how he would use that material for the protection of an armored ship-of-war. He had listened with much interest to the criticisms which had been passed upon that design, and he thought they might be summed up in this, that the ship was small. Every naval architect would agree that there was no fault in a design which was more easy to remedy than smallness. If the only fault that could be found with a man was that he was too young for his post, the obvious answer was that he would grow out of it. In like manner, if the severest stricture upon a design was that it was too small, the obvious answer was that it was easy to enlarge it. If the author were told that more coal was wanted in the ship, he would say, "It will take so many more tons displacement; I can do it." If he were told that it was necessary to increase the auxiliary armament, he would again reply, "It will take so many more tons, but it can be done." But in the case of a ship of 14,000 tons displacement, when the critic began by saying that the ship was much too large, then that there was not half enough coal, and then that certain portions of the ship were coated with 5 inches of armor where there ought to be 15 inches; in order to satisfy him, it would be necessary to take a clean sheet of paper and begin the design over again. The author had alluded to the Admiralty policy of taking up merchant cruisers and using them as fighting ships. He had stated elsewhere that it was quite possible to build such ships with their machinery below a bomb-proof deck, in which case they would be as easily defensible as a regular ship-of-war. It appeared to him that if such ships were built like the present Atlantic liners, but with their machinery covered by a 1½-inch deck, and with the new material stowed between the protective deck and another thin deck 2 feet above it, as in the author's design of a war vessel, such a ship would be as well defended as a cruiser of the Tage type; and he would ask the author whether he did not think that it might be wise for the Admiralty to build such ships protected in that way, and that instead of hiring inefficient war cruisers from the merchant navy, it might let out these vessels to the ship-owners for trading purposes. Of course the packing

material would not be put in until the ships were required to fight, and the space occupied by it would be available for cargo. All that the owner would have to put up with would be a certain permanent load imposed by the protective deck and a large engine-room staff, because two or even three screws would probably be required in order to keep the engines below deck. The gain to the country would be twofold: first, the present fast ships which, it would be remembered, were the only vessels which had a chance of running the gauntlet of hostile cruisers and bringing in the food supply, would not be withdrawn from the trade routes at the very time when they would be most useful; secondly, very efficient war cruisers might be made self-supporting, or even a source of profit to the nation instead of a constant drain upon its resources.

Dr. W. Pole, Honorary Secretary, while fully admitting the great public importance of the design of armored ships generally, remarked that the branch of the subject which most nearly concerned engineers was the construction of the armor, and its mechanical efficiency in affording protection. The author of the paper, though he had given some particulars, had said but little on this head, and it was somewhat surprising to find that, although for thirty years the subject had been so prominent as a national question, it had come so little before the Institution. The nature of the material to be used, its mode of manufacture, the design, form, and dimensions of the armor, the manner and amount of its resistance to shot and shell, the connections and fastenings, and many other points, were all questions purely belonging to the civil engineer; but, strangely enough, there was scarcely a reference to them in the whole of the minutes of proceedings. The Government had, however, thought it expedient from time to time to call in the services of engineers to their aid, and as Dr. Pole happened, at an important time, to have taken an active part in this way, he would ask leave to put on record some account of what had then been done. The author had alluded to the early opinions authoritatively given, about 1850, by British naval authorities, against the use of iron for naval war purposes. But the French were not so hasty, for a year or two afterwards, at the outset of the Crimean war, the French Emperor suggested the use of thick plates of hammered iron as a protection to floating batteries, which it was proposed to use in attacking Cronstadt, and an experiment was made in 1854 at Portsmouth by firing at a 4½-inch plate with wood backing. The result of this was that three such batteries were ordered by the

French Government and an equal number by the English. When the time came for their use, the British batteries were not ready, but the French ones were, and they were employed in the attack on Kinburn on the 17th of October, 1855. They were exposed to a heavy fire, at a distance of 700 yards, for about three hours, unsupported by the fleet, and at the end they came out practically uninjured. Such a test as this was conclusive, and from that date the utility of iron armor in protecting ships-of-war became an accomplished fact. The French lost no time in carrying the idea further, for they at once began building a large sea-going ship-of-war, of 5500 tons, protected on this principle. This vessel, now become classical under the name La Gloire, was launched in 1860, and was clothed from end to end in exposed parts with iron armor, some of it nearly 5 inches thick. Meanwhile the Kinburn success had gone far to dispose of the prejudices of the British dockyards, and the question of the claims of iron was re-opened by several experiments made at Portsmouth and at Woolwich, in 1856-1857 and 1858, with iron structures of various kinds. And, moreover, as the Government could not allow the French to steal a march upon it by the new-fashioned armor-clad man-of-war, it was decided to keep pace with them by constructing a similar ship, protected in the same way. This was the Warrior, a fine steamer of 9200 tons, which was launched in 1861. But, when the application of iron armor began to be seriously entertained, the Government found that it involved a multitude of questions, chiefly of an engineering character, which required the most careful and patient investigation, and it wisely decided that the whole subject should at once be submitted to a scientific committee, on which the engineering profession should be represented. This body, which afterwards became well known as the "Iron Armor-Plate Committee," was appointed by Mr. Secretary (afterwards Lord) Herbert, in January, 1861, and it consisted of six members; namely, Captain Dalrymple Hay, R. N., chairman, Major Jervois, R. E., Brevet Colonel W. Henderson, R. A., Dr. Percy, W. Fairbairn, and Dr. Pole. The members of the committee were in active work till the middle of 1864; they reported frequently and fully their proceedings to the Government, and their reports were printed in four folio volumes, with full illustrative plates. These documents were withheld from publication at the time for reasons of public policy; but after this interval there could be no impropriety in giving to the Institution a brief account of their proceedings, and of the results that followed therefrom.

The object intrusted to them was to investigate generally the application of iron to defensive purposes in war. Their first duty was to make themselves acquainted with the knowledge already existing on the subject, and this they did in two ways. In the first place they collected and reported on all the records they could find of previous experiments or investigations. These led to a general belief that iron was capable of forming a good protection, but still very little useful practical knowledge had been acquired, either as to the quality of material most efficient for the purpose, or the most advantageous mode in which it should be applied. The next step was to learn the views held on the subject by those persons best acquainted with it, and the committee accordingly invited the evidence of a great number of scientific and mechanical men who were likely to possess knowledge bearing on the subject. Among the witnesses were Sir William Armstrong, Sir Joseph Whitworth, General Lefroy, Captain Andrew Noble, Mr. C. W. Lancaster, and Mr. John Anderson, as eminent authorities on modern artillery; Mr. Scott Russell, Mr. Laird, Mr. Samuda, Mr. John Grantham, and Captain Hewlett, on naval construction; Professor Wheatstone, Mr. Mallet, Mr. Nasmyth, Captain Inglis, on the general scientific and mechanical treatment of the question, and all the most eminent iron manufacturers in the kingdom as to the properties of the material. The information given by these witnesses was extremely valuable, but their opinions were very conflicting on the novel points before the committee. Having thus obtained all the information possible, the committee began its own more special labors, and these consisted of original investigations, chiefly of a practical and experimental character, which were directed to two classes of objects: viz., first, the determination of a great number of points affecting the general application of iron for defensive purposes; and, secondly, to the direct trial, by ordnance, of special constructions, in the shape of targets designed and prepared for the purpose. The first and most important point was the nature of the material best adapted to resist the impact of shot. On this there was little positive knowledge, and the witnesses held great diversity of opinion. Some recommended soft and tough iron, others, steel of different kinds, and others, combinations of steel and iron. The committee tried an extensive series of experiments, which led to the conclusion that the most suitable material was simple malleable iron, the best kind being that which combined in the greatest degree the qualities of softness and toughness. It appeared that the use of defensive

armor-plates against shot was to resist the blow in such a way as would do the least mischief to the structure, and that the best mode of accomplishing this would be to make the plates of soft, tough material, which would allow the "work" residing in the shot to be absorbed in indenting and battering them without producing fracture. The committee directed much attention to the mode of manufacture of armor-plates. This, at the commencement of its labors, was quite a new thing, as no masses of malleable iron of such magnitude had previously been made. The first plates were made by hammering, but powerful machinery was soon erected for rolling them, and the rolling proved preferable for obtaining the quality required. The committee gave every encouragement and stimulus to the makers to improve their manufacture as much as possible. With this view the plan was adopted of inviting them to see the experiments and to study carefully the effect of shot on plates, giving them at the same time the benefit of all available information which could throw light on the subject. These opportunities were of the greatest use, for by no other means whatever could any such complete insight have been obtained into the nature of the problems to be solved and the conditions necessary for their solution, and further, this system of openness gave universal satisfaction to the trade. The iron-makers availed themselves willingly of the facilities afforded them, and the result was that, whereas at the appointment of the committee there were very few iron-masters who could make thick armor-plates, and those of very uncertain quality, there were at the end of the committee's labors many excellent makers, the dimensions had much increased, and the quality had immensely improved. At first the committee could scarcely rely on the quality of any plates above 3 inches thick; afterwards, 5 and 5½ inches became common thicknesses of approved quality, and some of the best samples were thicker still. The chemical composition of the various irons was accurately determined, and various metallurgical data were obtained. Careful comparisons were made with foreign irons, and it was fortunately found that armor-plates could be made with iron obtained from British ores, by the ordinary processes of smelting, and manufactured with mineral fuel, and not only equal but superior to foreign plates of much more costly production.

Another very important point of the committee's inquiry was the form in which iron could most favorably and economically be used for defensive purposes. Various opinions were held on the subject:

some authorities recommended a peculiar arrangement of bars, which previous experiments had favored; certain eminent engineers and ship-builders suggested a number of thin plates, well fastened together, a form which was thought to present great advantages for naval purposes in affording support to the structure, and at the same time offering great facility and economy of construction; while a great number of other schemes for bent plates, corrugations, ribs, bosses, and many other ingenious contrivances had their supposed advantages strongly urged. More than four hundred plans were submitted to the committee; these were all examined and reported on, and some of them were tried; but through all these complications the simple result was arrived at, that the best application was a single plate of uniform thickness, with the surface perfectly plain. It was found that a large size of plate was advantageous as giving fewer joints, although small plates were more trustworthy in quality, as well as much cheaper. At first it was supposed to be an advantage to connect the edges of adjoining plates by grooving and tonguing, and this was done in the Warrior, but it was shown to be a mistake, doing mischief instead of good, and was therefore abandoned. Another point of great uncertainty was as to the best mode of fastening armor-plates to the ship's side. Numberless schemes were devised for doing away with bolts passing through the plate, but experience showed that, with certain precautions, bolts and nuts were perfectly efficient. One of the latest experiments, however, gave remarkably good results with the French plan of large wood-screws holding into the backing behind. Great interest attached to the question of the backing most suitable for ship armor-plates. When these were first used, they were fixed directly upon the hull of timber ships, and when they were first applied to iron ships (in the case of the Warrior), it was thought expedient to imitate the former conditions by placing a thick layer of wood between the armor-plate and the skin of the vessel. Many objections were raised to this: the wood backing was said not only to be unnecessary but to be absolutely prejudicial, as liable to decay, and to destruction by fire and by shell. It was necessary that the committee should thoroughly test this, and elaborate experiments were designed and carried out for this purpose; but the committee was unable to recommend that this wood backing should be dispensed with, as it appeared to perform important functions for which no thoroughly efficient substitute could be found. The nature of the projectiles was a subject intimately connected with the resist-

ance of the plates, and a great number of experiments were made in conjunction with the Ordnance Select Committee, to determine the influence of variations in the weight, velocity, form, and material of the projectiles as regarded their effect on the armor. Discussions of the results obtained were given in two memoranda by Dr. Pole in January, 1862, and January, 1863.

In addition, however, to the determination of general principles, it was the duty of the committee to make trials of actual structures on the largest scale, for it was impossible to tell by any *à priori* reasoning or by any deductions from small trials how the armor of ships would behave under fire. The committee remarked:

"One of the most striking deductions from our experiments is the difficulty even for those most conversant with the subject to foretell what are likely to be results of untried schemes, however promising they may appear. The effect upon iron structures of heavy shot from modern ordnance is totally unlike the result of any other kind of mechanical action, and has conditions essentially peculiar to itself; experiments, therefore, on a great scale are absolutely essential to determine the merits of many plans still awaiting trial."

It was therefore determined to make targets on the actual scale, representing portions of the sides of ships armored in particular ways, and to ascertain their value in the most positive and unequivocal mode by firing at them with heavy artillery to the point of complete destruction. One of the earliest of these was a target representing a portion of the Warrior frigate, which, as already stated, had been built somewhat hastily in emulation of the French ship La Gloire. The target was 20 feet long by 10 feet high, and was composed of 4½-inch wrought-iron plates bolted to a wood backing 18 inches thick, behind which was the iron skin supported by wrought-iron ribs exactly as in the ship itself. The target was fired at in October, 1861, with many rounds of shot and shell from the heaviest guns then available, at 200 yards range, 3229 pounds of projectiles striking the structure; and although naturally much damage was done, the resistance offered was considered very satisfactory. This same target was again tried with heavier artillery than before, and the report was that no other target experimented on had offered so good a resistance. Many authorities considered, however, that it would be desirable to try other systems of protection, and accordingly several targets were constructed embodying different ideas. Two of these were on plans by Sir John Hawkshaw, one by Sir Wil-

liam Fairbairn, one by Mr. Scott Russell, and one by Mr. Samuda, all which, under fire, gave valuable information of some kind or another. And as the building of armored ships went on with modifications in their mode of protection, targets representing them were put to the proof, the Minotaur, the Lord Warden, the Bellerophon, and others being proved in this way. These and other ships were built expressly to carry out the designs drawn from the information obtained by the committee, and they represented the best knowledge and the most efficient protection attainable at that time. In 1864, at the instance of Dr. Pole, a target was made representing a system of armor which he had seen applied to a French ship building at Cherbourg; it involved some novelties, and the trial was particularly instructive. The attention of the committee, however, was not confined to ships only, but was largely devoted to the application of iron to permanent land fortifications. There were absolutely no facts on the subject of any value, and data could only be obtained by trials on a comprehensive scale. Accordingly, several structures were made of different plans that appeared feasible, and the result of the trials led to the development of satisfactory practical designs.

The members of the committee endeavored, throughout their work, not only to ascertain facts, but to reason upon them, and to make them useful for practical guidance. And when it is considered how little knowledge there was when they began their work, and that when they finished it they left the system of armor both for sea and land defenses fully and successfully established, it must be admitted that their four years' labors were not in vain. The great feature especially of the manufacture of the plates may be said to have been created under their auspices. In the twenty-five years that have elapsed since their labors ceased, no doubt great progress had been made, not only in the magnitude of the ships, but in the force of the artillery used against them, and the consequently larger scale of the armor; and it must, of course, be added that the new form of malleable material produced by fusion, whatever it may be called, had introduced great changes into the modes of preparation. It would be the province of others, who had the knowledge and the will, to give to the Institution information of these more modern improvements.

Sir Frederick Bramwell had nothing to remark on the engineering part of the subject, but he would like to refer to a question of political economy. Mr. Sydney Barnaby had proposed, in the interest of the ratepayers of the country, that the Government should make a certain

class of ships, capable of receiving "woodite" protection, which, when not wanted for the purposes of war, should be leased out to the carrying trade as merchant steamers. If that could be done, he said, such ships would be earning money instead of being a cost to taxpayers in the time of peace; also, that, when war came and ships were wanted to bring food to the country, they would not be withdrawn from the merchant fleet in the way they otherwise would be. Sir Frederick Bramwell desired on this suggestion to remark that, for Mr. Barnaby's proposal to succeed pecuniarily, it would involve that, in times of peace, merchants should hire Government ships, and should not build ships of their own; but as in time of war the Government ships must be withdrawn, and as by the suggestion the merchants would not have built ships, the vessels employed in the food trade would, when war came, be as much withdrawn as would be the ships owned by merchants, and there would still be the withdrawal of food-bringing ships. That would be one result, and the other would be that they would be allowing the Government to embark upon trading, which it was always too ready to do, competing with private capitalists, investing capital in the supply of ships and interfering with private commerce. He hoped that the Institution would always listen to anybody of the name of Barnaby, and certainly to Mr. Sydney Barnaby, with every respect to matters of engineering, but would be slow in adopting his views as to who ought to supply the merchant navy of the country.

Sir Nathaniel Barnaby thanked the members for the manner in which they had received the paper, with its many faults of omission, some of which had been happily corrected by Dr. Pole, and some faults of commission with which he should have himself to deal. With reference to the remarks of Admiral Sir George Elliot, he thought it was a great mistake to suppose that the rams of ships which had not armor carried out to the stem were therefore weak. The case had been quoted of the German ship the König Wilhelm, which ran into and sank a sister ship, and it was said that the ram was seen to be twisted out of its place, and that was urged against the use of rams as at present constructed. The present form of ram had been very largely influenced by the failure of the German ram that had armor carried out to the end, which armor completely failed to support it. The method was changed, and he contended, having had a good deal of experience in the matter, that it was impossible to have a stronger form of ram than that now used in the British ships-

of-war. If any one desired to convince him to the contrary, he would be happy to discuss the matter with him, but he believed it was impossible to have a stronger ram than that now in use, and he was certain that Mr. White would support that view. He regretted that he had not known of the great success which Messrs. Vickers had met with in their attempts to enter the field of armor-plate makers. That, however, was not his fault. The Admiralty had preserved its secrets well, and had resolved to keep undivulged all information as to who could make armor-plates, and, until the photographs were produced, he did not know how great a success Messrs. Vickers had achieved. He had singled out the firms of Messrs. Charles Cammell & Co. for special notice because they were the only ones in England who had made armor for modern ships-of-war, and he might be well excused for singling out those two great firms who had done such splendid service to the country. Captain Orde Browne had asked whether it was not possible to have hard armor for the cruisers to keep out the high explosives, and softer armor for the ships which were more heavily plated. To that, a naval officer near him at once objected very naturally that it was uncertain what explosives the enemy might discharge. That objection to the use of different kinds of armor in cruisers and battle-ships was good also against the use of different principles in applying armor in cruisers and battle-ships, and was the justification for his treatment of the French ships in the diagram. His contention was that the principles of armor defense should be the same in all classes of fighting ships. Look at the table of phases of armor. The Gloire, a French ship of 5500 tons, was designed to receive the attack of the fastest ships of that period, and to resist their shell guns. The Tage, of 7000 tons, was designed to do precisely the same thing. So also was the Dupuy de Lôme. Why, then, should he not compare them in the matter of armor defense? Sir Edward Reed and Mr. White had stated that he must not do so because they were called by different names. The Gloire was called a battle-ship; the Marengo and the Amiral Baudin were known as battle-ships, and the Tage and the Dupuy de Lôme were not. But in what respects would the enemy's guns treat them differently? In the last naval war the principle of defense was the same for all fighting ships. In the very largest ships there was the wing passage completely round the ship in the neighborhood of the water-line inside; and the business of the carpenter and his crew in an action was to watch the whole of that wing passage, and to have

plugs with which to stop up the holes that the enemy's shot made. It was inconceivable to him that any arguments could convince an assembly of engineers, called upon to hear and judge, that there was any justification for protecting the crew of one fighting ship with 10 tons of armor per man, and leaving the crew of other fighting ships without any armor, vertical or horizontal.

Sir Frederick Abel had drawn attention to conflicting statements in the paper as to high explosives. Yes, they were certainly conflicting. One set had been put forward by official people who were defending the use of 4-inch and 5-inch armor in new ships as a perfect defense against high-explosive shells. The other set supported his own views, that there could be no approximation to finality in the use of such armor. He had shown how the quick-firing gun and the automatic gun would be effective against it, and that the invention of armor-piercing projectiles loaded with those nitro-glycerine compounds, capable of piercing through even 12 and 14 inches of armor, must be expected. In a paper prepared by him last year for the Naval Construction Company he had said, "4-inch armor for this purpose is already obsolete before the ships are finished." Sir Frederick Abel had confirmed that. He had stated that experiments had proved that 4-inch armor would not always keep out high explosives; that it would be penetrated by armor-piercing projectiles which would carry the explosive charge through the armor. He had said that if the efficient application of high explosives depended only upon the provision of thoroughly reliable delayed-action fuze, then the naval officer might depend on having in the next war high explosives brought with perfect efficiency to bear against thick armor. In his paper he had asked whether it was only the enemy who was to take advantage of those powerful projectiles. He had also deprecated the use of such armor. He had wondered whether it had been put into the recent large Admiralty designs in deference to a school represented by the gallant officer, Lord Charles Beresford. That officer had stated that the Admiralty had started first of all with the theory that an armored battle-ship should not be sunk or put out of action unless its armor was pierced. He had himself always thought that where armor was used it should be endeavored to make it impenetrable. It was said that such impenetrable armor was useless if the ship could be sunk or put out of action while it remained unpenetrated. But, according to the new school, there need only be put on some thin armor which would be

speedily perforated, in order to set everything right. In order to put that armor on, the size of the ship must be increased at the expense of the number of ships; but no matter; the money expenditure per ship might be great, or the speed might be sacrificed, or thickness of armor or armament, in order to get some of that easily penetrable armor which would save the honor of the navy and justify the new school of naval architecture. It was said that the ship of 3000 tons was very small. His object in advising those who prepared the designs was to keep to a ship of minimum size for doing the work. That a ship could be made larger with advantage was no doubt true; but he thought the ship question fairly balanced all the qualities that could be got in a ship of the smallest size capable of fighting an action at sea. The ship was practically as large as the Asia and the Indus, the flag-ships of the Admiral Superintendents at Portsmouth and Devonport. He agreed with those naval officers who thought that any weather which would sensibly affect the comparative behavior of the ship of 3200 tons and that of 14,000 tons, would be found to be not fighting weather for either ship. Mr. White preferred an armored deck rising above the water-line in the middle, and sloping under the water to the sides, to the proposed raft body. He thought he was the first to introduce a deck under the water, with cellular divisions over it, in classes of ships which hitherto had been unprotected. That was in the C class of corvettes in 1878. He thought he was also the first to introduce the mode of defense preferred by Mr. White. That was in the Mersey class in 1883. If he should be the first to be instrumental in the use of the solid raft body in preference to either of those plans, he should think he had made a distinct and most important advance in the art of war-ship building. In bringing his paper before the Institution he had no desire to criticise any Admiralty work. He wished to direct attention to the new forces coming into the field, and to advise that outside engineering opinion should be taken before a large expenditure of money was finally decided upon. Since the Admiralty proposals had been made, they had been considerably discussed. They were said to have met with the acceptance of the navy. He had been listening that afternoon to an excellent lecture given by a naval officer, Captain Reade. The lecture was illustrated by beautiful drawings of ships, and it was a captivating lecture. The lecturer, however, had said some things about existing ships which he did not in the least agree with.

He stated that the new Admiralty designs were quite wrong, and he contended that the ships should have armor all over their sides, 6 inches thick. His view appeared to be that the design which the French had produced, of the Dupuy de Lôme type, was the one most needed for the largest ships. He had read with great interest a paper in the *Nineteenth Century* for May, by Lord Armstrong, and he should be glad to quote a few words from it:

"It will be noted," said Lord Armstrong, "that Mr. White is careful to avoid all questions as to the policy of building armored battle-ships in preference to ships of the cruiser class." He went on to say, "Although I am ready to commend the designs for these new ships, my distrust of the efficacy of all vessels of this armored class in relation to their cost remains unchanged. All the advantage they possess in point of defense is a partial and imperfect protection against artillery fire. As regards rams and torpedoes, they are as vulnerable as ships without armor at all, and they are as liable to perish by the perils of the sea as any other kind of war-ship, while their cost is so great that the loss of any one of them from any cause amounts to a national calamity. Mr. White, in his paper on these new designs, refers to what he calls the 'too many eggs in one basket' argument, but he wisely adds that he leaves that argument to be dealt with by the Board of Admiralty, who are responsible on matters of policy, he being only their technical adviser. The argument referred to is, however, undoubtedly possessed of great cogency, and to my mind the only justification for persevering in the building of such ships is that foreign nations are still doing so. Nevertheless, I maintain that we shall realize a greater amount by chiefly devoting our resources to the multiplication of vessels of the cruiser class in preference to those of the armored class."

Those were weighty words, and expressed almost what he had had in his mind in preparing the paper. He would only add another word. England possessed two sets of very able sons—sailors and civil engineers. He had the highest possible admiration for sailors, whom he knew well, and who were very splendid men; but when it was decided to enter upon a national policy in such an important stage of affairs—such crisis as the present—he thought that to shut out the great body of engineers, to whom questions of principle might be wisely referred, was a mistake. He thought every one would feel that if it had been possible for the Admiralty to lay before a body of civil engineers the outlines which were put

into Mr. White's hands (he was not now criticising the designs), it would have been much better than to enter upon a grave step in policy without such consideration as it ought to have received.

CORRESPONDENCE.

Admiral the Right Hon. Sir J. C. Dalrymple Hay observed that when Sir Henry Chads reported, in 1850, that "whether iron vessels are of a slight or substantial character, iron is not a material calculated for ships of war," he was justified by the character of the ship-plates of which some of Her Majesty's ships were being constructed. Substantial was a relative term, and the most substantial plate they applied to the sides of Her Majesty's ships did not exceed in any case ½ inch. These, under the fire of 32-pounder guns with cast-iron spherical shot and 8 or 10 pounds of powder, were driven in such masses of langrage that it would have been impossible for men to live behind them. It was not till 1854, after the failure of the Anglo-French fleet to effect on the 17th of October any material damage on the sea defenses of Sebastopol, that, on the initiative of Napoleon III., wrought-iron plates were applied to the sides of wooden ships to protect them against shell-fire. The first specimens tried in this country, at Portsmouth towards the end of 1854, were made under the tilt-hammer, and were 4½ inches thick. The spherical shells, at short range from 8-inch guns, broke up on striking, the plates received little or no damage, and the wooden structure was saved. He witnessed these experiments. The next opportunity of seeing an experiment was at Kinburn. The French had three floating batteries there, exposed at short range to smoothbore guns. Some men were killed by shot which entered the large broadside ports; but though the battery which he had an opportunity of visiting on that occasion had been struck sixty-three times by solid shot, no plate had been penetrated or broken, and no bolt had been broken In 1860 he was named chairman of the Iron-Plate Committee, and was associated with the late Sir William Fairbairn, Dr. Percy, General Sir W. D. Jervois, and Dr. Pole. It might truly be said that nothing was known of the manufacture of iron plates for protection against shot when that committee assembled; when it was dissolved in 1864, it left a record of experiments and opinions which even now, in the advanced stage of science, might safely be consulted. The Warrior, Black Prince, and Achilles were in process of construction, but the Minotaur, Agincourt, and Northumberland were constructed

in consequence of the advice of the Iron-Plate Committee; and the rolls by which the plates were constructed were put up by Sir J. Brown in consequence of evidence taken by the Iron-Plate Committee of the superiority of plates so constructed to those made under the tilt-hammer. The turret of Captain Coles led to the "raséeing" of the Royal Sovereign, and afterwards to the experimental fire to which she was subjected from guns of the Bellerophon. During the decade 1860 to 1870, several incidents occurred to make naval men skeptical as to low freeboard, breech-loading guns of large calibre, and the reliance upon a smaller number of large guns in preference to the broadside. Vessels of the Agincourt class had proved exceptionally fine sea-boats. They had assisted in laying an Atlantic cable; they had towed a dock successfully to Bermuda. The Royal Sovereign had been damaged in a contest with the Bellerophon, and the Captain, through being over-canvassed, had perished. One of the most formidable turret-ships ever built was thus lost, owing to the wish of the designer to make it also a sailing ship, against the advice of Sir Edward Reed, then Chief Constructor. The 40-pounder Armstrong breech-loader, with 8-pound charges, was ineffective against the 4½-inch plates, and a 150-pounder breech-loader gun jammed in the breech and was unable to be reloaded, in experiments at Shoeburyness. Thus it came to pass that want of confidence in a breech-loading gun capable of standing heavy charges, and the reliance upon many guns rather than on few, induced many officers of ability, such as the late Sir Cooper Key, to rely upon muzzle-loading ordnance and broadside ships. The resistance to an increase in the size of ships was intelligible. There was no need to build ships much larger than possible opponents.

Since the making of the Suez Canal, the Indian empire was deprived of the support of the Mediterranean fleet if its ships drew more than 24 feet and 8 inches. There was no advantage in increasing the risk on each individual ship, or increasing the cost, unless concentration of power was advisable for other reasons. The author had quoted accurately some remarks of his giving a general assent to Admiral Touchard's expressed opinion. He saw no reason to change the opinion then expressed. In specifying in their order the parts requiring protection, he saw no necessity to alter the respective values of the arrangement quoted. But, in the speech quoted, he previously stated that seaworthiness and speed were above all things necessary. He still adhered to that statement.

It must be remembered that in 1873 the torpedo was hardly developed, and the Polyphemus had not been tried. The torpedo might be guarded against by crinoline, but the ram could only be used or avoided by speed and handiness. This brought him to the special proposal of the paper. If the raft-bottom proposed could be made so as to receive the damage inflicted by the torpedo in such a manner as to lessen the risk of sinking, it would have most valuable results; but this material was, so far as he was aware, not yet even in the experimental stage, and he should be impertinent to offer any opinion on its merits. Small ships of this character would be invaluable, and have many of the advantages claimed by the author; but they did not, in his opinion, do away with the necessity for building large first-class battle-ships. They probably were an improvement on the Riachuelo, though four of them did not seem to be a substitute for the Victoria. How rapidly the march of science caused opinions to develop, and how difficult it must be for an outsider like himself to express a confident opinion, was illustrated by the fact that Sir Edward Reed and the author, two of the most eminent naval architects in the world, and who had each worn the blue riband of their profession as Chief Constructors of the British Navy, were not absolutely in accord on this subject, and neither of them, when in office even, so far as was known, submitted such a design to the public or the authorities. This country had been at war at the same time with France, Holland, Italy, Turkey, Russia, Denmark, Sweden, and the United States. The British navy then consisted of one hundred and forty-six line-of-battle ships in commission, and in 1807 Great Britain seized the Danish fleet at Copenhagen, and in 1808, the Russian squadron in the Tagus, in order that it might have as many battle-ships as all the world besides. This policy was carried out by Chatham and Lord Anson, by Mr. Pitt, Lord Howe, and Lord Barham, and was the only policy which gave this country absolute safety. This superiority was needed not at the end but at the outbreak of hostilities; wars were short, sharp, and decisive, and those best prepared, like Germany on a recent occasion, were successful. Other classes of ships might be extemporized, but a first-class battle-ship took four years to complete. It was better to spend money in building such ships, in case they might be wanted, rather than in paying a ransom after defeat. There were now one hundred and four first-class battle-ships in the world. Great Britain had thirty-four. It was proposed to build ten

new ones. To that must be added twenty-six with a speed and gun-power superior to the Italia, with a protection over the vital parts superior to the Italia's guns. As the offensive power of the Italia could be developed by direct fire in a line with keel of all its four guns, and as the bow in ramming was most exposed, so it seemed to him it was essentially needful that a narrow belt of protection at the water-line should be given, as the punching fire of quick-firing guns might possibly materially injure that portion of the ship.

Before closing, he desired to emphasize an opinion he had always ventured to express since the abolition of the Ordnance Office in 1855. The Ordnance Office was essentially a manufacturing department, though it was overlaid with detail of the Corps of Royal Engineers and Artillery. Those corps were justly attached to the War Office, but the construction of guns and the provision of munitions of war should be entrusted to a department separate from the two great spending departments. The nation might then hope to have guns ready in good time for its ships, and identity in make and calibre in the armament of its ships and fortresses. Until this was done he feared the difficulty in providing a suitable armament for ships would continue, and he could conceive nothing more fatal to the naval supremacy of this country than that a ship or a fleet resorting to Gibraltar or Malta should find guns and ammunition of a different character to that which they might require. England must be guided by the course of ship-building in nations which might be possible opponents, and for every battle-ship laid down by foreign countries a faster and more powerful ship should be commenced and rapidly completed here.

Major D. O'Callaghan, R. A., remarked that a tolerably long experience of armor-plate experiments at Shoeburyness led him to hail with satisfaction the proposal to abandon the type of unarmored fast-steaming cruisers, in favor of a vessel, which, while possessing the undoubted advantages of high speed and manœuvring power, would afford a measure of protection to guns and guns' crews from the disastrous effect of an enemy's shell-fire. With respect to ships which depended for their existence on speed alone, Englishmen were not fond of rapid strategic movements to the rear. Such evolutions were at times open to misconstruction, and captains whose orders were to hover on the outskirts of an engagement, and whose *rôle* was to convoy merchantmen or to bombard mercantile ports, would inevitably turn their blind eyes towards signals and would try conclusions

with ironclads in the thick of a fight, with the certain fate of destruction. The "plucky little Condor" incident would be repeated over and over again with less happy results. He well remembered the terrible effect of common and shrapnel shell fired some years ago at a section of the Shannon at Shoeburyness, and he made up his mind then that it was almost useless to protect the so-called vulnerable portions of such a ship—the engines, steering-gear, and magazines—when the fighting portions, the guns and their crews, were open to complete and total destruction by the feeblest projectiles. A delayed-action fuze for high explosives was not, as the author remarked, an accomplished fact, and shells filled with high explosives were powerless when fired against armor, unless the latter was very much below the perforating power of the gun opposed to it. There was little doubt, for instance, that 4 to 6 inches of hard armor, easily perforable by a 6-inch breech-loading gun, would be quite proof against a shell of that calibre filled with high explosive which would detonate on impact, causing the shell to break as harmlessly as an egg on the face of the armor. On the other hand a similar shell from a 9.2-inch or 10-inch breech-loading gun would probably overcome such a thin plate, detonate in passing through it, and though, as far as disruptive power was concerned, its explosions would probably be more local and less damaging to structure than that of a powder-filled shell, the number of man-killing fragments would be greater, and the execution in this respect proportionately to be dreaded. This effect, too, would, he took it, be quite independent of any fuze, delayed or direct in its action, but would be dependent solely on the disparity between the armor protection and the power of the gun. Steel-faced armor, 9 inches thick, such as the author proposed to use in the new type cruisers, was just perforable by a 6-inch armor-piercing steel shell at short range, but it would, he thought, keep out a shell filled with high explosive fired from a 9.2-inch breech-loading gun striking normally to its surface, and afford an efficient protection from even heavier shells striking at an angle. The effect of these projectiles, owing to the disruptive force being confined to a comparatively restricted area, might be discounted and localized to a great extent by the employment of traverses, and this, he would suggest, should be an important factor in future construction. On the general question of building four comparatively small ships instead of one large one, it would be presumptuous for him to express an opinion; but the policy must surely be sound, since the four ships were practically as invulnerable

as the one bulky ironclad, were more easy to manœuvre, and were susceptible of both independent and combined action. All the eggs were not in one basket, and the loss of one of the baskets would not necessarily involve the destruction of the other three.

Rear-Admiral R. A. E. Scott observed that the author's proposal was to build five small partially-armored ships of 3200 tons each, in lieu of every intended battle-ship of 14,150 tons; or else four ships of rather larger size and higher speed. The former were to steam 17 knots, and the latter, 19 knots an hour, as against the 17½ knots of the new battle-ships. The vessels proposed by the author were to be armed with two 22-ton guns each, and armored so as to protect the crews of these guns, which were to be mounted one on each side of the funnel, and to sweep round the horizon. The lower part of the funnel, together with the uptakes from the boilers, and the vital parts of these ships, were to be protected. The quadrupling of partially armored vessels, having their two guns, their crews, and funnels protected, and capable of steaming 19 knots an hour, would be of great advantage, could sufficient coal-endurance be given them; but unfortunately they could not, upon such small tonnage, carry coal enough to keep at sea for the lengthened periods requisite to defend the more distant commercial arteries, and were not, therefore, the ships which were so greatly needed for the protection of commerce. The utilizing 9-inch armor, so as to afford such a considerable amount of protection, appeared to entail the disadvantage of overheating the gun-chambers by radiation from the funnel; but, on the other hand, the author's calculations as to perforation by the 9.2-inch 22-ton guns of no less than 99 per cent of the area of the sides of foreign ironclads, was the most valuable contribution at the present time. He further stated that the 69-ton guns carried by the present battle-ships would only pierce ½ per cent more of this area, which must at once suggest the query whether the 69-ton guns were valuable in proportion to their weight of metal and of armor needed to protect them and their easily injured machinery. The author had pointed out Sir Thomas Hastings' mistake in condemning iron as the material for the skin of warships, but the same conclusion had been arrived at by all who witnessed the large pieces of iron which were torn off when the target was struck by projectiles. Latterly, great improvement has been made in the toughness both of iron and steel, but there was very little experience as to the damage likely to result from shell-fire against the unarmored sides of vessels. Shots were

unsuitable as naval missiles. Properly made steel shells would perforate any thickness that shots would penetrate, and then explode within the ship, as had been long since proved by Sir Joseph Whitworth. For steel shells, there was a safer and quite as powerful a material as any which had yet been manufactured abroad, and the mechanical ability to apply every kind of explosive in the best manner was likewise to be found in the United Kingdom. He believed that the proposed large battle-ships of 14,150 tons, or a few hundred tons more for larger coal supply, were the very ships now most needed for the navy, and the least likely to become obsolete. The author had directed attention to the imperfect gun-supply, and had shown the practical value of guns of 22 tons weight; but trustworthy 10-inch guns of about 30 tons would be still more suitable for ships, as their diameter would admit of the more powerfully explosive shells which would more quickly complete the destruction of the sides of an enemy's vessels.

PROFESSIONAL NOTES.

THE CORROSION AND FOULING OF SHIPS.—ANTI-FOULING COMPOSITIONS.

By M. HOLZAPFEL, *Newcastle-on-Tyne.*

[Reprinted.]

The invention of a means for protecting the bottoms or immersed parts of ships against fouling, and the worm in the case of wooden ships, and subsequently against fouling and rust in the case of iron ships, has long occupied human ingenuity. The Phœnicians over 2000 years ago already employed a composition consisting chiefly of asphaltum for this purpose, and relics of the ancient Romans prove that they employed lead and copper sheathing on the immersed parts of their ships. Before iron shipbuilding was introduced, as early as the middle of the 16th century, an anti-fouling composition was patented in this country; but after the invention of yellow metal, compositions in the form of paint were seldom used, till iron shipbuilding necessitated the use of a paint or composition to protect the iron against rust and fouling. Hardly a month now passes in which one or more patents are not applied for under the name of "anti-fouling compositions." This is a proof that the desire to invent a means for preventing the fouling of iron and steel ships occupies many minds. It is therefore surprising that there should be an almost total absence of literature on this subject, and that a perusal of mostly all the specifications which are filed from month to month should prove that even many of those who may be supposed to have given a great deal of time to the study of this subject should, to judge from their specifications, appear to be quite unaware even of the most elementary principles on which alone a successful anti-fouling composition can be based. In 1867 this subject was dealt with at considerable length by Mr. Charles F. T. Young, C. E., who gives the results of a number of important experiments by the British and French Admiralties and others, but who deduces from them the most conflicting and illogical theories.

At this year's meeting of the Institution of Naval Architects, Professor Lewes read a short paper, the outcome of a very exhaustive and painstaking research, but even he seems hardly to grasp the subject and to misinterpret some of the phenomena.

With our daily extending fleet of iron and steel ships, this question continues to grow in importance, and I will therefore endeavor to lay down the broad principles on which a successful anti-fouling composition should be manufactured.

The way to obtain this object is to imitate as nearly as possible the action of copper and yellow metal. When iron ships were first introduced, great difficulty was experienced to apply any substance which would even in a measure preserve the iron and prevent fouling for a reasonable period. Dry dock accommodation at foreign ports then was exceedingly limited, and a vessel could only be dry-docked after the return from her voyage. A man-of-war on commission in foreign or colonial waters, for an extended period would, before she came home and before she could get cleaned, become so foul as to be almost unmanageable and unseaworthy. What the government and private

shipowners hoped to attain at that time was a composition or material which could be applied to iron or steel ships and which would last for two, three or four years without being renewed. Many of the various patent compositions, whose manufacturers professed that they would achieve such a result, proved themselves entirely inadequate and barely lasted six or eight months. Others, besides fouling very rapidly, also corroded the iron to an alarming extent. In consequence of this, scientific and practical men endeavored to introduce a method by which copper, yellow metal or zinc sheathing could be applied to iron ships. Such methods did exist and are occasionally even now resorted to, but they could only be carried out at very great expense and at comparative loss in speed. The method adopted is to cover the iron under the water part of the ship with wood sheathing, 1 to 3 inches thick, and to nail the copper or yellow metal over this. There is however this drawback, that water is very liable to penetrate between the wood and iron skin of the vessel, and thus to cause corrosion, which remains undetected till the wood covering is removed. Moreover, the wood covering has to be fastened to the ship by iron or copper bolts, which in either case serve as a contact between the iron hull of the vessel and the copper sheathing, thereby setting up galvanic action, which is highly destructive to the iron hull of the ship.

Mr. Young, in the work above referred to, recommends, as the outcome of his experience and studies, to fasten zinc sheathing to the ship without an intermediate sheathing of wood. The fact that this method is out of use at present, although it was exhaustively tried, completely disposes of it.

The building of dry-docks in all important harbors of the world and the rapidity with which vessels are now cleaned and painted have made it unnecessary to have a composition which will stand as long as yellow metal. In any case it has been found desirable to dock ships at least once in twelve months to sight bottom, and therefore a composition which will keep a ship's bottom clean for twelve months in ordinary trades is at present likely to meet with the best success. It must moreover comply with the following conditions:

Firstly.—It must absolutely protect the ship against rust.

Secondly.—It must have a very smooth surface, so as to reduce surface friction to a minimum.

Thirdly.—It must be quick-drying, so that if necessary a steamer may receive two coats in one day.

Even if in a composition drying more slowly, better anti-fouling properties could be introduced, it is very doubtful whether such a composition would prove a commercial success, because the frequent chafing of our huge iron ships against piers, small craft, and anchor, chains, etc., removes considerable quantities of composition from the ship's bottom and thus exposes the iron to the action of the salt water, and it has been found absolutely necessary to recoat once in twelve months for this reason alone.

It is not difficult to make a composition which will in ordinary trades preserve the vessel against rust where she is not chafed and against fouling for such a period, unless she is exposed to exceptional delay in waters which are very productive of fouling matter.

Now, as to the anti-fouling properties, there are two methods by which they are supposed to be obtained:

Firstly, *exfoliation*, *i. e.* the separating of small particles of the composition from the main body, by which any animal or vegetable growth which may have attached itself is caused to drop off the bottom of the vessel; and

Secondly, the *poisoning*, by which the fouling matter is supposed to be killed either before attaching itself or after. Some scientific and practical men attribute the anti-fouling properties of copper, yellow metal and zinc sheathing solely to exfoliation, others to the poisoning principle only.

Mr. Young belongs to the former category, and Professor Lewes, without distinctly saying so in his paper, strongly leans in that direction. Both and all are in my opinion wrong, for it is only from the fact that copper and yellow

metal *only poison when they exfoliate* that they become anti-fouling, and it is only metals and compositions which in exfoliating produce poisons that are effective anti-foulers. Mr. Young, as well as Professor Lewes, give instances in their papers of cases where the galvanic action of the salt water on the copper has been neutralized by iron and zinc protecting bars, and where consequently a great deal of fouling was found on the copper. They both say that when the copper ceased to exfoliate it ceased to be anti-fouling, and they try to deduce from this that it is only the exfoliation which is wanted, not the poisoning. My argument is this, that when the copper exfoliates it produces a poison (oxychloride of copper) which is highly destructive to the lower animal and vegetable life, and that this poison is the *active anti-fouler* which kills the fouling matter before it can attach itself. Now, if the exfoliation of copper alone prevents fouling, why does not the exfoliation of metallic iron also prevent fouling? I may say that it does so to a very limited extent, but not because it exfoliates, but because by coming into contact with salt water the surface of the iron plate is transformed into rust, which also is to some extent poisonous, but not sufficiently to prevent fouling in any but the coldest climates. Now I think everybody present will bear me out that an iron plate when exposed to the action of salt water for four years will lose at least five times as much of its weight, *i.e.* will suffer five times as much exfoliation as a copper or yellow metal plate: if, therefore, exfoliation were the real and true factor which prevents fouling, iron itself should be a much more effective anti-fouler than copper.

Some people may argue that the success often obtained from the use of zinc white and tallow, which cannot be considered in themselves highly poisonous substances, is a proof that after all exfoliation, if not the only, is still an important factor as an anti-fouler. But zinc white and tallow when in contact with salt water become highly poisonous, and their chief merit lies in the poisoning principle. If a mixture of pure vaseline, mixed with chalk, were applied, the exfoliation would be equally good, but I need hardly say that the coating would quickly be covered with fouling matter to such a thickness as to stop the progress of exfoliation altogether. Exfoliation can only act as an anti-fouler in regard to substances which adhere lightly to a ship's bottom, not in regard to shell which seem to eat into the protective coating till they finally find a firm hold on the bare iron. I may, therefore, say that exfoliation is not an *active factor* which prevents the adhesion of animal and vegetable life, but a passive agent, which may under circumstances cause the formations which have already adhered to again detach themselves from the ship. For in dealing with the first developments of animal and vegetable life which constitute fouling, we have not a body heavier than water, which, if it does not find a sufficiently hard hold to keep on the ship would fall off by itself, but we have a hungry and most insidious animal or plant, which will live on anything that is not an active poison.

The poisoning principle is therefore this, that the anti-fouling substance must surround the ship with a thin layer of poisoned water which destroys all animal life that enters it; and you cannot poison an animal unless it absorbs some poison. So this poisoned zone gets gradually *absorbed* and must be replaced. This replacement is effected in copper sheathing, as well as in anti-fouling compositions, by a gradual dissolution of the main substance, which, in being dissolved, becomes highly poisonous. Mercury, copper, arsenic and zinc, in certain forms, are the substances mostly used for compositions, and they must be used in a varnish which will dissolve with sufficient rapidity to admit of these substances continually combining with salt water, and at the same time with sufficient slowness to retain part of them for the length of time for which the vessel will be exposed to the influence of fouling. We may now take it as granted that a successful anti-fouling paint must contain a considerable amount of poison which will destroy animal and vegetable life in its lowest developments; and that this paint must slowly dissolve, or corrode, or, if you like,

exfoliate. Whether these poisons are poisons in the ordinary acceptation of the word, or not, does not matter, they must merely be poisons to the class of animals and vegetables which try to attach themselves to a ship's bottom, and they must carry the greatest possible efficacy in the smallest possible volume, and as already stated these animals and vegetables must be poisoned in their first stages of development, in which only they try to attach themselves to a ship or other solid substance, for when they have once attached themselves they grow rapidly, and can stand a great amount of various sorts of poisons, which is evidenced by the fact that a mussel can thrive on a quantity of *verdigris* which would poison a healthy man, also by the fact that large sized shells several inches long are not infrequently seen on copper sheathing where they could not fail to absorb a large amount of poison from surrounding parts of copper. It will be seen therefore that even *copper* is not a perfect anti-fouler when exposed to trying circumstances, when, for instance, animal and vegetable life in the surrounding water is so strong that all the small particles of poison get absorbed, and before new formations of poison can take place the animals attach themselves to the ship.

Now when they have once attached themselves the poisoning factor generally becomes useless, the animals grow and the ship comes home foul, often to the astonishment of the owner, captain and composition manufacturer, and this not only occasionally takes place with the best compositions, but also with *copper* and *yellow metal*.

I referred above to preparations of mercury, copper, arsenic and zinc. All of these are supposed to cause corrosion of the iron, particularly copper, which consequently should not be used at all, or only to a very limited extent. But in each case the anti-fouling coating should be separated from the iron by a coating of anti-corrosive paint. Many years ago red lead was taken for this purpose, but it has now been almost completely displaced by quicker-drying and more protective varnish paints, which should be so constituted that even if they are exposed to the action of the salt water, their dissolution would be so slow and gradual as to be almost imperceptible. Many vessels of the mercantile marine have such a solid and hard body of these protectives on their bottom that absolutely no rust can be seen on them except on places where the paint is chafed off. As to the anti-fouling, or second coating, I have already stated that the varnish conveying the anti-fouling ingredients should be so constituted as to allow of a gradual but very slow dissolution in salt water, so as to set the anti-fouling or poisonous matter free. Now in varying waters varnishes of various hardness may be used, in the tropics a soft and rather quickly dissolving varnish, in northern waters a hard and slowly dissolving varnish.

In an experience of over 10 years I have absolutely satisfied myself that most mercurial varnish paints on competitive trials will invariably show a better result than any other compound, while the preservation of the iron and the smoothness of the surface are unequalled. These paints, moreover, are so cheap, and dry so rapidly, that the total expenditure of a steamer for docking, cleaning and painting during four years is considerably less than a single outlay for docking and sheathing with yellow metal, which under favorable circumstances will only last the same period, *i. e.* four years. It seems to me very doubtful whether a composition lasting longer than 12 months, provided it were dearer than those now in use, would meet with favor, because most shipowners are already under an obligation to their underwriters or the Board of Trade to dock their vessels at least once in 12 months (which, moreover, is desirable in order that the sea-cocks, propeller, rudder, etc., may be inspected), and the cost of anti-fouling paint, if intelligently bought, is a very small one indeed. The tendency, on the contrary, seems to be to economize further in the cost of the paint, and to dock the ships more frequently, for the prices for dock dues and labor for painting, and the time required for this purpose, are in most parts only one-third or one-fourth of what they were 15 years ago, while the additional speed of a newly cleaned and painted bottom is a great desideratum. The only

improvement, therefore, which may be looked forward to might be the substitution of mercury by some cheaper substance which would be at least as destructive to fouling matter as mercury. I foresee no chance of a compound being invented which would be hard enough to withstand chafing and which could at the same time be used to convey sufficient anti-fouling materials in a suitable and effective manner. All we can therefore expect from the immediate future is comparative perfection within the radius in which we now move, *i. e.* a perfect adjustment of the various gums used in preparing varnishes and of the various anti-fouling materials now known, so that the composition may be quite reliable even in cases where the various paints now used sometimes fail to fully answer their purpose.

DEPARTMENT OF DISCIPLINE.

The following order is published, as it is believed that all interested in the Naval Academy will be glad to see it. Many have recognized the necessity of giving as much weight as possible to officer-like bearing and aptitude for the service, so as to bring forward those who are particularly well adapted to naval duties, standing well in their studies, but not the best students, while possibly the best naval officers. Gradual progress has been made in this direction by giving weight to marks in certain practical exercises, then to the marks received on the cruise for proficiency in the various duties of officers on board ship, and now by the establishment of the Department of Discipline. By weekly changes in the section leaders and daily changes in the officers of the day and cadets in charge of floors, with the frequent practical exercises, each cadet will come under the observation of a number of officers, will receive a number of marks to determine his monthly and term standing; and the result should approach as near to the true value of the cadets as in other studies, and should be as accurate as is possible under any system for ascertaining relative class standings. The coefficient allotted to the new department is sufficiently large to prevent any cadet from taking a high standing in his class unless he stands well in the department.

U. S. NAVAL ACADEMY,
ANNAPOLIS, MD., *January* 25, 1890.

ORDER.

With a view to taking cognizance of officer-like conduct and efficiency in the performance of duty on the part of the cadets, and as being calculated to raise the military tone of the Academy and aid materially in the selection of the most efficient officers for future service in the navy, the Department of Discipline is hereby established, with the approval of the Navy Department, on the following basis:

First. Said department shall be under the direct management of the commandant of cadets, as head of the department, who shall submit to the superintendent monthly, semi-annual, and annual reports of the standing of all cadets in their respective classes in "efficiency and attention to duty," and in "conduct." Said reports shall be made in accordance with the system of marks now established for other departments.

Second. In making up the standing of cadets in their respective classes, the commandant of cadets shall require and make use of daily reports of the efficiency and attention to duty of cadets from the officers on executive duty, and of weekly reports of the same, based on daily marks, from the instructors in all departments. Cases of misconduct and of inattention to duty on the part of any cadet shall be reported, as now required by regulations, and demerits shall be assigned, after investigation, by the commandant of cadets. The column

headed remarks in each report must contain a concise statement by officers in charge and by instructors in different departments, of the reasons for assigning marks for "efficiency and attention to duty."

Third. In order to give to officers in charge and to instructors the fullest opportunity for observation, in addition to the daily detail of cadets for special duty, the commandant shall, as soon as the monthly section arrangements are published, make out a detail of cadets as section leaders, to serve as such for one week in turn, changing each Monday.

Fourth. In making up the monthly standing for each class in the department of discipline, the following system shall be observed: The average of the marks for "efficiency and attention to duty" shall be combined with the mark assigned to "conduct" from demerits received, giving an equal weight to each branch. In assigning marks for conduct, which shall be done in accordance with the demerits received during the month, the following system shall be observed: The cadets in each class shall be considered as satisfactory in conduct when the number of demerits received during a month does not exceed—

for the first	class	13
" second	"	18
" third	"	22
" fourth	"	37

For each demerit received during the month there shall be subtracted from 4—

for the first	class	.1154
" second	"	.0833
" third	"	.0682
" fourth	"	.0405

A negative average *may* thus be obtained.

Fifth. In case any cadet shall have marks for "efficiency and attention to duty" alone, or for "conduct" alone, in any month, he shall not be given class standing in the report for that month.

Sixth. The standing for any term in "efficiency and attention to duty" shall be the mean of the monthly averages in that branch, and the standing in "conduct" shall be the mean of the monthly averages in that branch, and the mean of these two shall be the term average in the department of discipline.

Seventh. The time from the annual examination to the 1st of October in each year shall be considered as a third term for this department, and the final mark for the year shall be the mean of the three term marks.

Eighth. Marks for performance of duty and aptitude for the service on board the practice ship shall be considered as belonging to the department of discipline.

Ninth. The yearly coefficient of the department for each class shall be as follows:

first	class	16
second	"	12
third	"	8
fourth	"	4

the coefficient for studies in other departments being re-arranged so that the maximum for the whole course at the Academy, as now established, shall not be changed.

Tenth. Weekly reports shall be made and published of all cadets who are unsatisfactory in "efficiency and attention to duty" or in "conduct."

Eleventh. The department of discipline shall be organized, and the above changes shall take effect immediately on the conclusion of the semi-annual examination for the present year, February 1, 1890.

W. T. SAMPSON,
Captain, U. S. N., Superintendent.

THE COMPARISON OF THE INDICATIONS OF TESTING MACHINES WITH THOSE OF THE STANDARD.

Steel and other metals contracted for by the government and by private parties are constantly being tested in many different localities and on many different machines, and a ready means of comparing the indications of the different machines with the standard is desirable.

A very satisfactory comparison was recently made between the Rodman and the Riehlé hydraulic machines of the Department of Ordnance and Gunnery, at the Naval Academy, by means of the spiral pressure gauge used in guns. Five disks were subjected to a pressure of about 20,000 pounds in each machine, and the mean pressures and turns of the spiral compared. The results were as follows:

RIEHLÉ MACHINE.			RODMAN MACHINE.		
No. of disk.	Pressure.	Turns of spiral.	No. of disk.	Pressure.	Turns of spiral.
1	20,400 lbs.	10.9	6	20,100 lbs.	10.75
2	20,000 "	10.7	7	20,900 "	10.9
3	21,400 "	11.1	8	20,000 "	10.7
4	20,100 "	10.6	9	20,000 "	10.4
5	20,000 "	10.7	10	20,000 "	10.4
Mean,	20,380 lbs.	10.8	Mean,	20,200 lbs.	10.63

The spiral gauge is described on page 168, Proceedings U. S. Naval Institute, XIII, No. 2. Such a gauge, if constructed for use only with a testing machine, would be somewhat simpler and less expensive in construction.

The inspectors should be required to subject the standard disks sent to certain specified pressures in the gauges. The disks should then be numbered and returned to the central office with the record. The whole matter would then be under the control of the chief inspector, who could compare the indications of all the machines with those of the standard.

Such a method would seem to be more accurate and thorough than the present practice of testing different strips from the same plate in the machines to be compared, as well as less troublesome and expensive.

C. S. S.

BALLISTIC-PHOTOGRAPHIC EXPERIMENTS IN POLA AND MEPPEN BY PROFS. E. MACH AND P. SALCHER.

[Translated by LIEUT.-COM. E. H. C. LEUTZÉ, U. S. N., from *Mittheilungen aus dem Gebiete des Seewesens*, Pola.]

Owing to the great interest which the account of former experiments with rifle projectiles excited, we were enabled to make further ones on a larger scale with projectiles fired from cannon. Some of these experiments were made in Pola by Mr. Salcher, under the patronage of the naval authorities of Austria, while others were made in Meppen by Mr. Mach and his son, by invitation of the firm Frederic Krupp. These experiments are in a measure supplementary to each other, as those in Pola were made with larger caliber (9 cm.) and less velocity (448 m. sec.) than those at Meppen (caliber 4 cm., velocity 670 m. sec.), where different shaped projectiles were also introduced. The arrangement of the physical apparatus differed in the two cases and will therefore be described separately, beginning with that of Professor Salcher.

1. Professor Salcher used as head of his "Schlieren apparatus"* a telescope

*See Proceedings, XIV, 1, 1888.

objective belonging to the Prague Physical Institute, which had an aperture of 21 cm. and a focal length of 3 m. The photographic lens was a "rapid rectilinear" made by Dallmeyer. Tin tubes were placed between the illuminating apparatus and the optical parts, to dim the light and keep off the direct rays of the sun. After the apparatus had been placed in optical adjustment, the jar charged and the cannon loaded, an electro-magnetic current was established by a key; this current opened the camera and at the same moment closed another current which fired the gun. The first current was instantaneously interrupted and the camera thereby closed.

The caliber of the steel-bronze piece used was, as before mentioned, 9 cm., its length 23 cm., the initial velocity 448 m. sec., and the distance from the muzzle of the gun to the head of the "Schlieren apparatus" 18 m.

The apparatus fulfilled all expectations, although the experiments in open air take place under much less favorable circumstances than those in a laboratory.

The head-wave appears as a broad hyperbolic-shaped stripe, which is a little further in advance of the projectile than that of the shot of the Werndl rifle. It has, however, the same angle of inclination to the path of the projectile, which is undoubtedly due to the almost equal velocities in both cases. This wave reaches to the cylindrical part of the shot and is therefore limited by v, v, v', v', fig. 1. Inside of this space a peculiar wave, which surrounds the head of the projectile and points to some peculiar phenomenon, will be noticed.

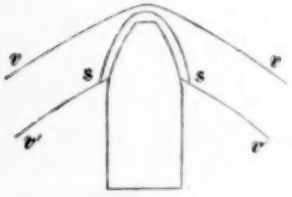


Fig. 1.

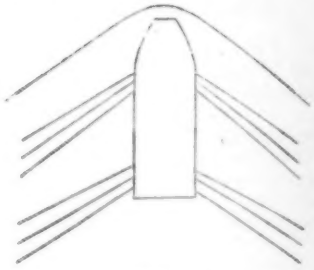


Fig. 2.

The photographs show, besides this head-wave, a series of other waves, which emanate from the body of the projectile. As the points of origin of these waves seem to coincide with the position of the expansion rings, it seemed at the first glance that these rings were the cause of the disturbances; but as these waves also appear with great regularity and equal distances, though in different groups, with smooth projectiles, they must be due to the shape, size, and velocity of the shot. To the little irregularities on the surface of the shot can therefore be assigned only a secondary modifying influence.

These waves seem to be caused by friction, analogous to the waves produced on water by the wind.

The wave lines caused by the 9 cm. projectile are typical. Three diverging stripes emanate from the forward pair of expansion rings and the same from the after ones, but these latter make much larger angles with the axis of the shot (see fig. 2).

At the base of the projectile will be seen the disturbance caused by the air entering into its wake. Behind the Werndl projectile (cal.= 11 mm., v. = 438 m. sec.) this disturbance looks like a glittering stream, similar to rising, heated air. The 9 cm. projectile, with its insignificant difference of velocity, presents a similar aspect. The inrushing air shows a streakiness which makes the picture look as if the projectile was tailed with a bunch of feathers. This simi-

larity results from whirls which really begin close behind the forward expansion ring and surround the projectile in a widening envelop to the base, where they enter into its wake.

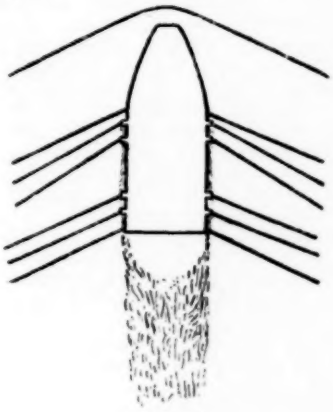


Fig. 3.

2. A special apparatus was constructed for the Meppen experiments. The principle originator of it was Mr. E. Mach, while his son, Mr. Ludwig Mach, worked out the details of construction. Special care was taken in all the arrangements, as the apparatus had to work even during unfavorable weather.

In order to avoid any unnecessary loss of charge, the illuminating jar, which was charged by an induction machine, could not be taken into the circuit until a proper potential had been attained. Immediately after that had to follow the opening of the camera, the firing, and the closing of the camera. The electrical parts of the camera are shown in fig. 4.

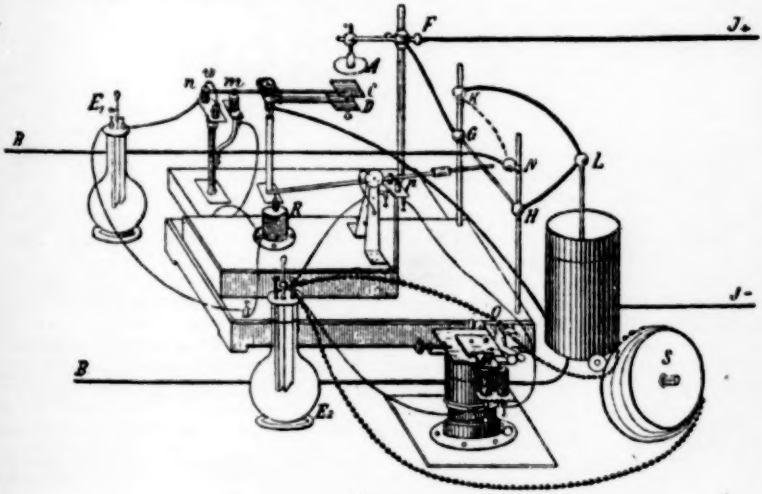


Fig. 4.

From the positive pole $J+$ of the self-exciting induction machine the circuit goes over F, G, H, to the inner coating of the jar L. The potential can be regulated by the position of the plate A. The negative pole $J-$ is connected with the balance beam C of the other part of the potential regulator. As soon as the potential is high enough, C, which is negatively excited, will be drawn to the positively excited plate A, which causes the other end of the beam, which has a wire loop, to dip into the quicksilver reservoirs N, and is then held in that position by the electro-magnet M. By this a connection is made with a battery which is in the drawing indicated by E. The current from E draws an iron core into the coil R, thereby lifting with the other end of the lever (to which the core is attached) the rod GH to the position KN. This interrupts the current between the induction machine and the jar, but shunts it into the circuit which leads to the spark-producing terminals BB. At the same time a current leading to another battery indicated by E_2 is interrupted by lifting the electro-magnetic current interrupter out of the reservoir p. The interruption of this current, which, in connection with M, kept the camera closed, allows a spring to open it, and at the same time strikes a gong at the firing place. The firing and closing of the camera (by hand*) follow immediately. In this manner a proper charge of the jar was assured—an important matter, for had it been too small, the shot might not have caused discharge, and had it been too great, a premature discharge would have taken place.

Everything worked with great accuracy, and the whole transaction occupied less than a second.† The apparatus never failed.

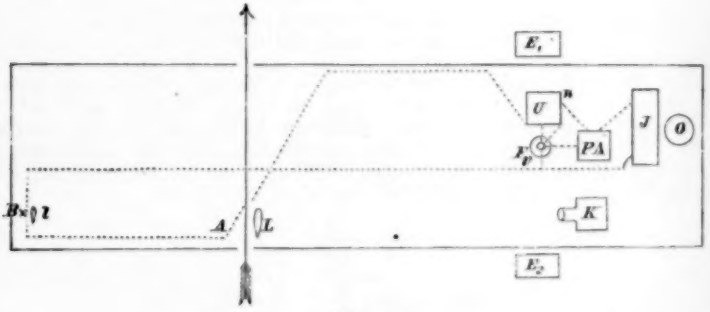


Fig. 5.

The entire arrangement of the installment can be seen in fig. 5. The whole apparatus was enclosed and the light deadened by a wooden hut (14 m. long, 2.5 m. wide), with two openings in the line of flight of the projectile (indicated by the arrow). From the induction machine J near the store O the circuit leads over the potential regulator P, the jar E and the current interrupter U to A, where the shot closes the circuit, thence to the place of the spark B, and further to the outer coating of the jar, and back to the other pole of the induction machine. The batteries E and E_2 of 8 Bunsen elements each, were outside of the hut.

The optical parts of the apparatus, namely, the illuminating apparatus B, with the achromatic lens l (5 cm. aperture, 30 cm. focal length), the head of the Schlieren apparatus L (21 cm. aperture, 3 cm. focal length), and the cam-

* This closing could of course have been done automatically, and would be recommended were the apparatus to be a permanent one.

† The man firing the gun was so expert that it was hardly possible to notice a time interval between the sounding of the gong. We considered that we had to abstain from electric firing on grounds of personal safety, and would advise against it in similar cases.

era K are of course in a straight line. The distances are $Bl = 25$ cm., $lL = 4.5$ m., $LK = 6$ m. The light of the spark B, passing through l, fills the aperture L completely, so that it, L, looks brightly illuminated as seen from K.

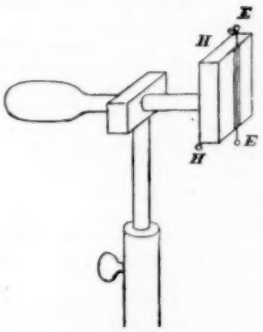


Fig. 6.

The illuminating apparatus is represented in fig. 6. It consists of a parallelopiped of hard rubber, which can be moved horizontally, vertically, and also around the line of sight as axis. A small shallow groove contains the electrodes of magnesium wire, and is covered with a glass plate after the hard rubber has been painted with petroleum. This arrangement obliges the spark to extend in a straight line, and can therefore be made parallel to the edge of the opaque screen * which is placed in front of K. This causes great increase of light, and makes it possible to use a very small spark of very short duration. The capacity of our jar was barely 1000 cm.

The adjustment of the optical parts is made as follows: The different parts are placed approximately at the above mentioned distances, and the center of B, l and L and the objective of K are placed approximately at the same height. The lenses l, L are then removed and the frame of L so placed that its image will be in the center of the ground glass plate of the camera K; the frames of l and B are then so placed that their images will be concentric with that of L. If then the lens l is replaced and a candle-flame is held in front of K, its reflection on l will show if the axis of the lens coincides with lK. The axis of the lens L is adjusted in the same manner.

In order to place B in the proper position, so that the image of the spark will be projected on the screen in front of K, and preferably so that it will be bisected by the screen in the direction of its length, a candle-flame, or, better still, a platinum wire made incandescent in a Bunsen flame is used. This flame or wire is placed immediately in front of the screen and opposite to the center of K, and at the same parallel to the edge of the screen at the place where the image is to appear. If the spark-score B is then placed so as to appear in the well defined part of image of the candle-flame or wire, then reciprocally the image of the spark B will coincide with the candle-flame or wire.† A small after-adjustment of the screen or small movement of K completes the installation. During our experiments the screen was placed vertically and generally to the left, looking in the direction of L.

The muzzle of the gun was distant 12 m. from the place where it caused discharge, *i. e.* A. The projectile here formed the connecting bridge between two parallel, vertical wires of 0.5 mm. thickness; these were covered with rub-

*See XIV, 1, 1888.

† By application of the optical law of reciprocity, the problem is, as in case of a geometrical construction, considered solved; but it becomes necessary to seek for the conditions of this solution.

ber and were about 3 cm. apart. The projectiles used were blunt, caliber 4 cm., length 6, and others pointed at both ends so as to leave at each end a circle of 16 mm. diameter, caliber 4 cm., length 9.8 cm. The velocity in front of the lens *L* was about 670 sec. m.

The fear that the pressure of air would cause disturbances was found, if not without foundation, at least greatly exaggerated. The shock of the discharge had no appreciable effect on the independently placed parts of small diameter of the apparatus. The illuminating apparatus only, which besides being placed in the sand had to be fastened to the wall of the hut, had to be readjusted. The shock, however, produced no movement in the wall of the hut until too late to disturb the experiments.

The pictures which were taken were on the whole similar to those obtained by firing rifle projectiles, and proved the correctness of the assumption formerly expressed, that the experiments with small models were sufficient provided the velocity was the same. There were, however, some new phenomena; the wave in front of the blunt projectile showed double; the part closest to its head seemed to be apparently an isolated, flat disk of air which seemed to disperse sideways.

The double-pointed projectile showed, besides a single head-wave, three isolated waves which emanated from the sides of the projectile at different places.

We will not give an exacter description or analysis of the pictures, as we have since, during many varied laboratory experiments, obtained still better pictures, of which we will treat later.*

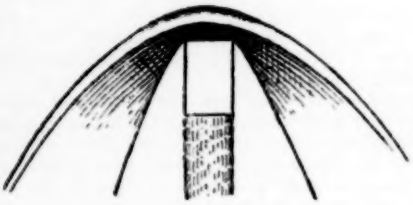


Fig. 7.

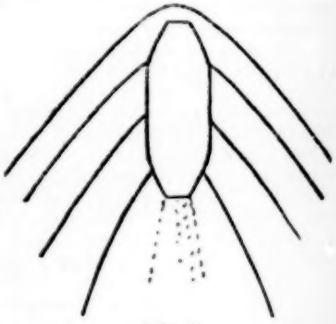


Fig. 8.

We have no doubt that even with smaller and less expensive installation, valuable experiments can be made at artillery proving grounds. We also hope that this will be done, and we will be very happy to give any further and more exact information. With this view we have arranged the apparatus so, and given such a detailed description, that even a person with little practice should obtain good result.

We give special weight to the experiments at Pola and Meppen because they proved in presence of several experts that our method can be employed in the study of common projectiles.

* During later experiments it became possible to make quantitative determination.

BOOK NOTICES.

PRACTICAL MARINE SURVEYING. By Ensign Henry Phelps, U. S. N.

While this book was written to fill the need of a suitable text-book on the subject at the Naval Academy, it thoroughly bears out its title and is eminently practical, and will be found useful by all who wish to acquire a knowledge of marine surveying. There have been a number of books written on this subject, but this is the first one that is really practical and by means of which any one with sufficient education to handle the instruments and make the calculations can learn to make a good marine survey. It contains many valuable "wrinkles," some of which have been passed along for years in the Coast Survey, and others that are the result of experience in the survey of the Western Coast under the Hydrographic Office, Navy Department.

AMERICAN RAILROAD BRIDGES. By Theodore Cooper, M. Am. Soc. C. E.

In this work Mr. Cooper gives a history of American bridge-building, together with a description of the existing and accepted types and the methods in use to-day, and it cannot fail to be of interest to all who design, manufacture or use railroad bridges. In the historical portion, under the head of wooden bridges he commences with the "Great Bridge" built across the Charles river, between Old Cambridge and Brighton, in 1660, and carries it along to 1844, when the Pratt truss was patented, in which the tension members were of iron. Under the head of iron bridges he commences with Thomas Paine's letter, written in 1803, and ends with the iron lattice bridge built 1865–66 over the Connecticut river. He then takes up the history of long-span bridges, commencing with the bridge built 1863–64 over the Ohio river at Steubenville, and continuing the history up to the present day. He then gives the theory and practice of designing and proportion, a description of the manufacture of bridges, of the typical American railroad bridges with a discussion of their relative merits, and concludes with a discussion of the failure of bridges. There are a number of plates and some tables giving the result of physical tests of full-size bridge members. R. W.

BIBLIOGRAPHIC NOTES.

ANNALEN DER HYDROGRAPHIE UND MARITIMEN METEOROLOGIE.

17TH ANNUAL SERIES, VOLUME IX. Proof of Poisson's theory of the deviation of ships' compasses by means of observations. Sailing directions for the China Sea. Length of voyages of iron and wooden sailing vessels from Europe to the Bay of Bengal and return. Currents in New York bay and harbor. Pampero in the SE. part of the mouth of the La Plata. Meteorological observations on Butaritari Island in the Gilbert Archipelago. Quarterly weather review. Minor notices: Ice in the South Atlantic; Chemical analysis of the water of the North Sea; Current measurements in the North Atlantic; Currents in the Straits of Belle-Isle, also on the west coast of Newfoundland; Currents near Cape Bon, Tunis, Guantanamo, Cuba, Vera Cruz, Mexico; Currents in the Mozambique Channel; Voyage from Manilla to Zebu; Reports on the harbors of Wellington and Napier in New Zealand and Iquique; Description of a water-spout.

VOLUME X. Remarks on strength and velocity of the wind at Norwegian lighthouses. Remarks on several points on the SW. coast of Africa. The island Santa Maria. Port Adelaide and Port Germain, Australia. Sailing directions for Bahia Blanca, Argentine Republic. Description of and sailing directions for the harbor of Castries. Current and water temperature observations, west coast of Africa. Quarterly weather review, fall of 1885. Minor notices: Sailing directions for the rivers Casamanza and Nuñez; West coast of Africa; Remarks on Bramble Cay and Eastern Fields Reef, eastern entrance to Torres Straits; Remarks on Bulhar, east coast of Africa, also Berbereh; Sailing directions for the river Salum, west coast of Africa; Extension of the Boca Channel, near Buenos Ayres; Remarks on the Paracel Island, China Sea; Remarks on Runs Channel, southern entrance to Moreton Bay, Queensland, Australia; Time signal at Capetown; Anchorage near Hodeidah, Red Sea; Bottle post from different vessels.

VOLUME XI. Current measurements off the new entrance to Wilhelmshaven. Voyage of H. M. S. Olga from Sydney through Torres Straits to Aden. Extracts from the log of Captain Reniers, of the barque Aeolus. The coast of Abacama between Autofagasta and the river Loa, Chili. Dust-storms in the North Atlantic. Quarterly weather review, fall of 1885. Minor notices: Remarks on

Caen, on the French coast, English Channel; Caleta Buena; Extraordinary weather phenomena off Akyab; Running down the trades to the leeward of San Antonio, Cape de Verdes; Sickness resulting from the eating of fish; Bottle post from several vessels.

VOLUME XII. Compensation of compasses for deviation caused by the electric lighting installation. Remarks on harbors on the west coast of Africa. Remarks on Fusan, Corea. Extracts from the log of H. M. S. Carola, voyage from Zanzibar to Aden and return. Passage of Atlas Strait. Sailing directions for the harbor of San Blas, Argentine Republic, also for Khor Ambada, Bay of Tejureh, Gulf of Aden. Deep-sea sounding and exploration of banks in the Pacific. Butterflies in the South Atlantic, long distances from the land. Minor notices: An interesting weather phenomenon in Jubal Straits; Remarks on the Boma mouth of the Malimba (Edea) river; Sailing directions for Gibraltar; also for the river Ponga, west coast of Africa; Depth and bottom off Montevideo; Remarks from the meteorological journal of the German bark Inca; Extracts from the log of the German bark Olga; Voyages of the German ship Ferdinand Fischer, west coast of America.

E. H. C. L.

BOLETIM DO CLUB NAVAL.

NOS. 10 and 11, JULY AND AUGUST, 1889. Hints on the study of elementary naval tactics. Theory of the rudder (continued). On the history of the Brazilian navy. Movements of the squadron.

J. B. B.

BOLETIN DEL CENTRO NAVAL.

JUNE AND JULY. The hydrography of the Parana and Uruguay. The fisheries of Patagonia.

AUGUST. Submarine navigation. A. C. B.

DEUTSCHE HEERES-ZEITUNG.

OCTOBER, 1889, No. 79. Experiments with homing pigeons for military purposes in Italy.

These interesting experiments, which took place between the military lofts of Rome and Civitavechia, a distance of 65 km., have demonstrated the possibility of using the *same* pigeons to perform a *double* service, namely, of carrying messages *from* Rome *to* Civitavechia and *vice versa*. These remarkable results were obtained by feeding certain pigeons in one loft only (that of Civitavechia), and keeping their young ones in another at Rome, thus compelling them to make regular trips from one place to the other to get their food. These experiments are of especial value, as they insure uninterrupted communications with an invested place without fear of exhausting the supply of the carriers.

Naval matters: building of new ships for the German navy; Raising the blockade of the East African Coast at Zanzibar; Explosion of a gun on board the practice vessel La Couronne near Hyères, France.

No. 80. Attack and defense of submarine mines for coast defense. Experiments with homing pigeons (concluded).

No. 81. The annual military manœuvres in Germany, near Hannover, under direct command of Emperor Wilhelm.

The novel features of these manœuvres were, 1st, the use on the field of small movable protected towers provided with rapid-firing guns; 2d, the use of smokeless powder on a large scale both for artillery and infantry.

Description of the torpedo-vessel Vesuvius, of the U. S. Navy.

No. 84. Review by F. v. S. of the prize essay for 1888, on Torpedoes, by Lieutenant-Commander W. W. Reisinger, U. S. N., published in the Proceedings of the United States Naval Institute, Vol. XIV., No. 3.

No. 88. The ironclad Friedrich Karl. Construction of new cruisers for the German navy at Kiel.

No. 90. Estimates for the German navy for 1890–91=88,781,165 marks.

No. 91. Review of an article by Capt. Zalinski in the *Electrical Review*, N. Y., on the use of electricity to ascertain the position of the enemy in coast-defense operations. Launching of the protected cruiser Jean Bart, at Rochefort, France. Fortifications on the Thames, England.

No. 92. Use of magnesium flash-lights in the navy.

No. 93. Description of the electric submarine boat Goubet, France.

No. 94. England: building and launching of new vessels for the English navy.

No. 95. Krupp's gun trials. New type of the Whitehead torpedo from the Royal laboratorium at Woolwich. Building and launching of new cruisers for the English navy.

DECEMBER, 1889. No. 98. Notes on the defects of the ordnance in the English navy. United States: different opinions by American naval officers on the pneumatic dynamite guns of the Vesuvius (from the *Admiralty and Horse Guards Gazette*).

No. 100. Publication of the official register of the German navy for 1890. England: launching of a new cruiser for the Australian squadron, and other vessels. New English torpedo-stations.

No. 101. Return of the aviso Pfeil from the blockade of the East African coast. New apparatus for launching torpedoes, invented by R. Soutwarth Lawrence, London (Middlesex). United States: further notes and opinions on the Vesuvius.

No. 102. England: ammunition for heavy ordnance. Defects in the construction of the cruisers of the Bird type. H. M.

THE ENGINEER.

OCTOBER 12, 1889. An alleged fraudulent stamping of boiler plates. Manganese bronze. Building vessels in the navy-yards.

OCTOBER 26. Coal armored cruisers. The performance of the Baltimore. Horse-power standards for marine engines.

NOVEMBER 12. Multi-cylinder engines. The strength of alloys at different temperatures.

NOVEMBER 23. Foreign opinions of the Chicago. Horizontal air pumps. Heating by exhaust steam.

DECEMBER 7. Miscalculated ships. Guns and armor. Double screw ferry-boats. Rapid-fire guns for the Lakes.

DECEMBER 21. Steel stay-bolts. Design and construction of chimney-shafts. Forced draft.

JANUARY 4, 1890. Corrosion and scaling of marine boilers. Forced draft. Spontaneous combustion in coal. J. K. B.

JOURNAL OF THE AMERICAN SOCIETY OF NAVAL ENGINEERS.

NOVEMBER, 1889. Graphic determination of crank effort. Evaporators. Tests of Corliss boilers. Contract trial of the Charleston. A compressed air system of forced draft.

A description of a method of using compressed air in a practically open ash-pan applied to a small steam launch at the Mare Island Navy Yard. The arrangement consisted in having a small air compressor of the same diameter as the high pressure cylinder, made out of a 4-inch boiler tube, with composition valve-seats screwed on each end, and the piston driven from the crosshead of the high pressure engine. The compressed air was conducted to the front of the ash-pan, where it was delivered into a nozzle forming a part of the ash-pan door. Several trials showed that with a pressure of 1½ to 2 inches of water, the combustion of Wellington coal of good quality was about 30 pounds per square foot of grate. The draft by this system of delivering air into a practically open ash-pan is largely an induced draft. In the particular case mentioned, the air supplied by the pump was not more than ten per cent of that theoretically required for the combustion, the remaining ninety per cent being supplied by induction.

The advantages claimed for this system are that the mechanism is inexpensive and with but little liability to derangement. It is economical and noiseless. Freedom of access to the ash-pan. As compared with the use of a blower driven by an auxiliary engine, there are points in favor of this system. In the first place the blower must supply the entire volume of air needed for the combustion of the fuel, the ash-pan being closed in the usual way in which a blower is used in small launches. The result of the high velocities is rapid wear which requires no little attention. The first cost of the machinery is considerable.

The contract trial of the Baltimore. Measured mile trials at Newport of the Chicago, Atlanta, Boston, and Yorktown. Casualties and repairs. J. K. B.

JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES.

NOVEMBER, 1889, to JANUARY, 1890. Mills and mill engineering. Electric motors. Notes on a new compound steam turbine. Recent developments in iron and steel manufacture. J. K. B.

MECHANICS.

OCTOBER, 1889. Steam engineering at the Paris Exposition. Compound Corliss engine. Boxes and journals. The Teal portable hoist. Units of power. A new thermometric scale.

NOVEMBER. The Girard-Barre hydraulic railway. The strength of alloys at different temperatures.

In studying some experiments made before the Admiralty, Professor Huwin's attention was directed to the remarkable decrease in the tenacity of gun metal when the temperature was raised. At 350° there was a sudden decrease of tenacity, generally about 50 per cent, and at a temperature of 500° the tenacity had become nil. In the present experiments rolled bars of yellow brass, Muntz metal, Delta metal, gun metal and cast brass, were tried. The results were all plotted in a diagram, and show that in all cases the decrease in strength follows a regular law without any such sudden loss of strength as was shown in the Admiralty experiments. Even at temperatures of 600° to 650° all the bars had still a not inconsiderable tenacity. The ultimate elongation of the bars was also measured. There is a peculiarity in the influence of temperature on the ductility of the bars. In most cases the ultimate elongation diminishes with increase of temperature. With Muntz metal the decrease is regular, with considerable elongation before fracture at a temperature of 650°. With cast and rolled brass the decrease is more rapid, and there is very little elongation before fracture above 500°, while the elongations of gun metal were very irregular.

The indicator and its use. Compound locomotives. The economical production of motive power. The Hertz experiments. The trial of the dynamite gun. A new Swedish explosive.

In Sweden has recently been invented a new explosive which so far has given great satisfaction. It is called "gray powder" (Swedish grakrut), and has, during the summer, been tested at Rosersberg Gunnery School, and also has been accepted for trials in the fleets. According to official reports, the gray powder has been used with 25-millimeter as well as with Nordenfelt's machine guns. The former has, with 70 per cent of the new powder against 100 per cent (or the usual charge) of the ordinary powder, given a 33 per cent greater initial velocity without the pressure in the gun being increased more than 5 per cent. With regard to the important question of smokelessness, the report states that while with Nordenfelt's machine guns, smoke of ordinary powder remains for twenty-five seconds, the gray powder only leaves a transparent steam which is visible for but five seconds.

DECEMBER. Report of the annual meeting of the Society of Mechanical Engineers.

JANUARY, 1890. Steam boiler design. An improved connecting rod. The indicator and its errors. Machine design. J. K. B.

MITTHEILUNGEN AUS DEM GEBIETE DES SEEWESENS.

VOLUME XVII, NO. 10. Treatise on the three arms of modern naval battles and the tactics determined by them. Remarks on steel and compound armor plates. Launching of the Russian armor-clad Imperator Nikolaj I. Estimates for the Imperial Austrian navy for 1889–90. Laying down of the Russian armor-clads Gangut and Grosjasci. Armor-clad vessel Siegfried of the Imperial German navy. Attacks of torpedo-boats during the manœuvres of the French navy. Gaubet's submarine boats. Torpedo-boats using petroleum for fuel. Floating docks for torpedo-boats. Repairs of submarine torpedo-launching tubes. Torpedo-boats for the Imperial German navy. Torpedo gunboats for English navy. New air compressor

at the Paris Exposition. French torpedo-boats at the Paris Exposition. Apparatus for cutting torpedo-nets. Organization of torpedo-boat divisions in Russia. Sinking of a Danish torpedo-boat. New line of steamers. Exposition at New Zealand. Arctic exposition of Fridtjof Nansen. Literary notices: Torpedoes and torpedo warfare, by C. Sleeman, late Lieut. Royal Navy; Seaman's Handbook, by A. Muchall Viebrook; Treatise on Maritime Sports.

VOLUME XVII, NO. 11. Protection and preservation of the bottoms of iron and steel vessels, by Seaton Schroeder, Lieut. U. S. navy. Geometrical solution of problems of electrical discharge. Jury rudders. Trials of the Beauchamp-Towers constant platforms. Improvement on water-tight doors. The Taryan condensing apparatus. Experiments with 36-pound rapid-firing cannon in England. Trials of the pneumatic guns of the Vesuvius. Types of torpedo-boats for the English navy. Experiments with torpedoes at Constantinople. Halpin-Savage torpedo armored gunboat La Grenade. English gunboat Sparrow. English cruiser of the third class Barham. The English battle-ships Royal Sovereign, Repulse, and Renown. Speed of some English war vessels. New English cruiser of the first class. Putting in commission of the Turkish vessel Ertogrul. Turkish torpedo-boat Schanawer. Building of a new Turkish cruiser. Steel-castir[illegible] in Constantinople. Rebuilding and altering of Turkish armored vessels. Manœuvres of Turkish torpedo-boats. Pump vessel for the Turkish navy. Société centrale de sauvetage des naufrages. Movements of vessels in Algerian harbors. Russian harbor improvement in the Black Sea. The lighting of the coast of the Argentine Republic. New steamer lines. Literary notices: Building of river vessels, iron, wood and composition; Principal harbors in the world; Current observations in the Indian Ocean. New edition of Captain Marryat's novels; German harbors; Explanation of abbreviations, etc., used on home and foreign charts; Naval warfare, a strategetical study of the English fleet manœuvres of 1888; Political and military significance of the Caucasus. E. H. C. L.

NORSK TIDSSKRIFT FOR SOVAESEN.

8TH ANNUAL SERIES, VOLUMES 1 AND 2. The review at Spithead. Merchant fleets of different countries (from *Nautical Magazine*). The English fleet manœuvres in August, 1889. Stranding of the German men-of-war at Apia. On the fouling of iron and steel vessels (from *Nautical Magazine*). French navy. Minor notices: The course of the abandoned American schooner W. S. White; The International Maritime Congress; The latest English armor-clad vessel; Largest sailing vessels; New Italian torpedo-boats; Additional remarks on the English fleet manœuvres.

VOLUME 3. Maxim-Nordenfeldt automatic gun. Luminous night-clouds. Additions to the merchant fleets of different countries. Short visits to the dockyards at Copenhagen, Kiel, and Karlskrona. The United States navy. Derelict vessels. Minor notices: The

Italian cruiser Piemonte; Speed trials in the English fleet; The Medea type of vessel; The cruisers Blake and Blenheim

E. H. C. L.

PROCEEDINGS OF THE INSTITUTION OF CIVIL ENGINEERS.

VOLUME XCVIII. Armor for ships. The treatment of steel by hydraulic pressure, and the plant employed for the purpose. Experiments on a steam engine, the cylinder of which was heated externally by gas flames. Investigation of the heat expenditure in steam engines. The improvement of the river Avon below Bristol. Experiments on the strain in the outer layers of cast-iron and steel beams. The cyclical velocity. Variations of steam and other engines. Balanced slide valves. On the new programme for shipbuilding.

THE RAILROAD AND ENGINEERING JOURNAL.

NOVEMBER, 1889. Engineering in naval warfare. Irrigation. The world's shipping. Cable towing on canals. A new Chilian battle-ship. The development of armor. United States naval progress.

A review of the report of the trial of the Charleston, and the tests of the guns of the dynamite cruiser Vesuvius.

French criticism of our ships.

DECEMBER. On stresses produced by suddenly applied forces and shocks. A propeller for light-draft boats. An English view of the American navy.

An extract from the *Army and Navy Gazette*, commenting on the remarkable strides which have been taken by the United States in the rehabilitation of the navy. Commenting on the arrival of the squadron of evolution in European waters, it states that it is not so much that the United States have made a very good beginning towards building of a modern navy, but there have been developed in the country facilities of every kind for the creation of that navy without outside aid. This can hardly be said of any other power except France and Great Britain. Not only has much been done in the way of constructing vessels which are as good as anything, but arrangements have been made by which they will be able shortly to create entirely from their own resources every modern implement of war, including steel-clad battle-ships of the heaviest tonnage, with their guns and armor.

United States naval progress.

The launch of the San Francisco, the report of the board to report a plan for the development of the League Island Navy Yard, the work now in progress at the Washington gun factory, and the report of the board upon the question of consolidating the naval establishment at Newport.

The development of armor. A French naphtha launch engine.

JANUARY, 1890. The development of armor, by Lieutenant Califf, U. S. army. Quadruple expansion engines for S. S. Singapore. A new Russian battle-ship.

The latest addition to the Russian navy is the armored battle-ship Nicholas I., which was begun in 1886, and was built by the Franco-Russian Company under contract. The vessel is of steel, of Russian manufacture, while the

armor-plates were made at the Admiralty works at Ijorski. The chief dimensions of the Nicholas I. are as follows: Height between perpendiculars, 333½ feet; length over all, 347½ feet; breadth, 67 feet; average draft, 23 feet; displacement, 8440 tons.

Propelling on light draft. The Burgin high-speed engine. United States naval progress; a synopsis of the annual report of the Secretary of the Navy. Notes on the New York Naval Reserve.

J. K. B.

REVISTA MILITAR DE CHILE.

No. 36, SEPTEMBER, 1889. Extension of the Central Railroad of Chili. Arms in use in different countries. On the defense of the Chilian coast. Notes on the "Great Captain," Fernandez de Cordova. On the employment of cavalry in raids. The uses of modern artillery.

No. 37, OCTOBER. Examinations in military schools. Studies on the de Bange system. Extension of the Central Railroad of Chile (continued). Treatise on military hygiene. On the employment of cavalry in raids (continued). The uses of modern artillery (continued).

No. 38, NOVEMBER. The National Guard. On open order in military operations. On the establishment of Le Creusot.

No. 39, DECEMBER. On mobilization of troops. The Pfund-Schmidt torpedo. The electric light in searching for wounded.

J. B. B.

REVISTA MARITIMA.

No. 2, AUGUST, 1889. Naval reforms. Use of oil in storms at sea. Sea-going torpedo-boats. Notes on Brazilian naval history. The dynamite cruiser Vesuvius. Naval warfare. On explosives.

SEPTEMBER, 1889. The ports of Liverpool and Birkenhead, with plates and descriptions of docks and basins. Regulators for arc lamps. Historical study of steam navigation. The French naval manœuvres. On coaling men-of-war (translation). The Society Islands and the natives of Polynesia.

OCTOBER, 1889. Arctic exploration. On penetration of armor-plates. Notes from observations taken at Krupp's works. Liverpool and Birkenhead (continued). Study on the composition of fleets. The Hicks machine for throwing shell charged with high explosives (translation). The Society Islands and the natives of Polynesia (continued).

NOVEMBER, 1889. Combined military and naval operations. Arctic exploration (continued). Liverpool and Birkenhead (continued). On naval mobilization (reproduction of portions of article by Lieut. S. A. Staunton, U. S. N.) Geography of the sea. The evolution of the torpedo-boat. Boilers in the new English men-of-war. Trials of the Spanish submarine torpedo-boat Peral (with illustration).

DECEMBER, 1889. Combined military and naval operations (continued). Liverpool and Birkenhead (concluded). On the penetration

of armor-plates (concluded). The question of heavy guns in England. The Society Islands and the natives of Polynesia (concluded). Photographing projectiles in motion (translation). J. B. B.

REVUE DU CERCLE MILITAIRE.

OCTOBER 6. Execution of counter-attacks by troops of all arms. The "Sud-Oranais" expedition of 1881, Algeria (continued). The military exhibit of 1889 (continued).

OCTOBER 13. The Dutch army.

OCTOBER 20. Regulations for infantry drill. The military exhibit.

OCTOBER 27. Regulations for infantry drill (end). Two days at the school of firing at Le Mons.

NOVEMBER 7. Regulating the fire of a field battery by the mere observation of fuzing shots. The "Sud-Oranais" expedition (ended). Remount of officers and requisition for horses in Italy.

NOVEMBER 10. Strategic transportations.

NOVEMBER 17. Infantry tactics. Battle formation of the company, the battalion, and regiment.

DECEMBER 1. The moral education of the Russian soldier. The defense of Plevna (with cuts in the text)

DECEMBER 8. The defense of Plevna (continued). The smokeless powder: its influence upon tactics.

DECEMBER 15. The defense of Plevna (ended).

JANUARY 2, 1890. Renewing the supply of ammunition to the artillery. Moral education of the soldier, and particularly of the trooper. J. L.

REVUE MARITIME ET COLONIALE.

OCTOBER, 1889. The cohorts of the Legion of Honor (end). Note on the use of the deflector for regulating the compass at sea. Verifying the compass route of the ship by means of luminous guiding marks (repères). An ingenious device which allows the helmsman, the quartermaster, and the watch officer to verify at night the ship's course, at one glance and without reading the points of the compass.

NOVEMBER, 1889. Action of heated iron hulls upon the deviations of the compass. Depopulation of the sea, and the advisory board on sea fisheries. Historical studies on the military marine of France (continued). The end of large fleets. Oceanography (statics).

DECEMBER, 1889. The tides in the Lower Seine, by Adm. Cloué. The Cape Horn mission (continued). The hurricane of March, 1889, in Samoa. Oceanography (statics) (continued). J. L.

THE SCHOOL OF MINES QUARTERLY.

NOVEMBER, 1889. Incandescent lamps. The performance of certain multiple expansion marine and pumping engines.

A series of tables compiled for the use of investigators on the boilers, engines, pumps and condenser of various marine and pumping engines, with their dimensions and performances.

Summary of useful tests with the blow-pipe. The total solar eclipse of December 22, 1889. J. K. B.

THE STEAMSHIP.

OCTOBER, 1889. Electric lighting. The corrosion and fouling of ships. Anti-fouling compositions. Feed-water heating. Morton's reversing valve-gear. Note on Bremme's valve-gear. The new cruiser Barham.

The engines of this vessel have the distinction of being the lightest in the service for the power to be developed, their weight being less than those of the Barrosa, which has only to indicate 3000 horses, while the Barham has engines of 6000 horse-power. The lightness of the machinery, which is a repetition of that of the Bellona, has caused much comment among naval engineers. The standards which usually support the vertical cylinders have been dispensed with and exceedingly light framing substituted. This framing is, however, tied together by longitudinal and diagonal girders. The Barham is without the protection of a double bottom, and in order to economize weight, the plummer blocks are placed directly upon the bottom plating of the vessel without the intervention of the usual head plates. To give stability to the engines, the cylinder of each set are connected together by stops passing through the dividing longitudinal bulkhead. The engines on the port and starboard sides respectively are also tied by girders to the protective deck above. As the Barham is intended for the speed of 19½ knots per hour, the engines are especially designed for quick running, the power developed being secured by the exceptional number of revolutions—230 per minute.

NOVEMBER, 1889. Notes on Bremme's valve-gear. Forced draft.

A paper read before the Institute of Marine Engineers, giving the various systems of artificial draft that have been tried, together with a discussion of their relative values.

Morton's reversing valve-gear. Bilge pump.

DECEMBER, 1889. Broken shafts.

A discussion of the causes of breakage in the shafts of sea-going steamers. To avoid breakdown the author recommends (1) an efficient governor, (2) a flexible coupling, (3) built crank-shafts; and when great power has to be transmitted, hollow steel screw shafts instead of solid wrought-iron ones.

The coaling of steamships. The Pamphlett-Ferguson distilling apparatus. A Canadian ship railway. Launch of the Australian cruiser Phœnix. The obliquity of connecting rods. Smith & Cowan's patent marine boiler.

JANUARY, 1890. The Elsmore copper depositing process. The modern marine boiler.

A paper read before the Junior Engineering Society by Mr. Lilly, on the design and construction of modern marine boilers.

The twisting moment diagram of a triple expansion engine. Means of increasing the speed of steam vessels. Radial valve-gears.

J. K. B.

THE STEVENS INDICATOR.

OCTOBER, 1889. Experimental mechanics as developed in foreign technical schools. Testing machines. Efficiency. On the use of ropes for prong brakes.

JULY, 1889. Energy-relation of gas and electric lighting. The charging of blast furnaces. The mechanics of the injector. Examination of olive oil for adulteration. A chimney paradox.

J. K. B.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (TRANSACTIONS).

VOLUME X, 1889. On the use of the compound engine for manufacturing purposes, the relative areas of the cylinders in the compound engine and the regulation of the pressure in the receiver. Foundry cupola experience. Electric welding. The distribution of internal friction of engines. Some tests of the strength of cast iron. The cost of power in non-condensing engines. The flow of steam in a tube. A simple calorimeter. The mechanics of the injector. The identification of dry steam. The friction of piston packing rings in steam cylinders. The comparative cost of steam and water power. Cylinder ratios of triple expansion engines. Improved motion device for engine indicators. The piping of steel ingots. Formulas for saturated and superheated vapors. Longitudinal riveted joints of boiler shells. Steam consumption at various speeds. Use of crude petroleum in steam boilers. Some properties of vapor and vapor engines. J. K. B.

AMERICAN SOCIETY OF MINING ENGINEERS (TRANSACTIONS

Aluminium in cast iron.

A paper prepared to substantiate the statements made in an article upon the same subject read before the American Association for the Advancement of Science, in August, 1888, together with the chemical analyses of the test bars belonging to the casts reported in that paper. J. K. B.

TRANSACTIONS OF THE CANADIAN SOCIETY OF CIVIL ENGINEERS.

VOLUME III, PART I. The Panama Canal. Cantilever bridges. The development of the locomotive. The Esquimault Graving Dock Works, British Columbia. J. K. B.

TRANSACTIONS OF AMERICAN SOCIETY OF CIVIL ENGINEERS.

SEPTEMBER AND OCTOBER, 1889. A discussion on the construction of the Sibley bridge over the Missouri River. Cylindrical wheels and flat-topped rails for railways. J. K. B.

THE UNITED SERVICE.

VOLUME III, NO. 1. Our coast defenses. Modern naval education. The United States Revenue Cutter service. Comity in the

mess. The army as a home. Some cavalry leaders I have known. Among our contemporaries.

No. 2. Glances at the wars of to-morrow. Curious phases of naval warfare. The United States Revenue Cutter service. Our coast defenses. Operations before and fall of Atlanta. A grand palaver.

No. 3. The Indian as a soldier. The modern law of storms. The United States Revenue Cutter service. Great commanders of modern times. Among our contemporaries.

UNITED SERVICES GAZETTE.

NOVEMBER 2, 1889. Torpedo, gunnery, hydraulic and pilotage courses. Royal Naval School. Dockyard economies. The Vesuvius.

NOVEMBER 9, 1889. Imperial federation. The Victoria's 110-ton guns. Steel guns for the American navy. India since the mutiny. The American "New Navy."

NOVEMBER 16, 1889. Lord George Hamilton and Mr. Stanhope on the services. Our monster ordnance. Sights and laying. Engine-room artificers, R. N.

NOVEMBER 23, 1889. Mr. Forwood on the navy. The twelve-pounder. The stoker question.

NOVEMBER 30, 1889. The value of case shot. Sir Edward Watkin on the Channel tunnel. Lord George Hamilton on the navy. Launch of war vessels. The Australian defenses. Gun trials of the Camperdown. Naval uniforms.

DECEMBER 7, 1889. Naval uniforms. Modern drill and tactics. An American view of the late naval manœuvres. Imperial federation. The Portsmouth Royal Naval College.

DECEMBER 14, 1889. Vice-Admiral Sir Anthony Hiley Hoskins, K. C. B. H. M. S. Victoria. The Royal Navy. Engine-room artificers and their grievances.

DECEMBER 21, 1889. The repair of H. M. S. Amphion. The Royal Navy. The naval uniform question. The right of way at sea.

DECEMBER 28, 1889. Canada and the United States. Arrival of the Sultan. The Sharpshooter class. The Maxim gun.

JANUARY 11, 1890. Machine guns. The defenses of St. Helena and Cape Colony. Naval retrospect, 1889.

JANUARY 25, 1890. The tactics of coast defense. Court-martial. Out of sight, out of mind. Protective and anti-fouling composition.

FEBRUARY 1, 1890. Modern gunpowder as a propellant. Naval uniforms. Steam reserve economies.

LE YACHT.

OCTOBER 12, 1889. Editorial on the slow promotion of officers in the French navy; case of the ensigns. The French five-masted

sailing ship France; sail plan and longitudinal plan amidships. The merchant marine exhibit at the Paris Exhibition.

OCTOBER 19. The coming International Marine Congress. The new cruisers of the United States; sketch of the Baltimore. Judges' decision in the late British manœuvres. Notes from foreign ship-yards. The merchant marine exhibit at the Paris Exhibition.

OCTOBER 26. Naval policy of France and foreign nations for the year. Argument against torpedo-boats. Review of the merchant marine exhibit at the Paris Exhibition.

NOVEMBER 2. Compound boilers of the steamer Calorie plan. Description of the Collingwood; profile and deck plan. Launch of the Greek cruiser Spetsia.

NOVEMBER 9. The different shapes given screw propellors. Naval notes. Comparison of promotion of officers in England, Russia, Germany, and France. Description and plan of Mr. Bennett's yacht Sereda.

NOVEMBER 16. Editorial on the resignation of Amiral Krantz, Minister of Marine. Engines and boilers at the Paris Exhibition. The British battle-ship Royal Sovereign. Review of the merchant marine.

NOVEMBER 23. Engines and boilers at the Paris Exhibition. Notes from foreign ship-yards. Effect of subsidies on the merchant marine.

NOVEMBER 30. Launch of the French cruiser Alger. Sketch of the British battle-ship Benbow.

DECEMBER 7. Editorial on the appropriation of fifty-eight millions of francs. British protected cruisers of the first class. Review of the merchant marine.

DECEMBER 14. Editorial on the French navy. French submarine boats. A new four-masted sailing ship Le Nord.

DECEMBER 21. New ships to be constructed (editorial). The Chinese protected cruiser Chih Yuen; sketch.

DECEMBER 28. Description and sketch of the cruiser Vesuvio of the Italian navy. Notes from foreign ship-yards. Review of the merchant marine.

JANUARY 4, 1890. A review of the increase in European navies, 1889–90. Report of the Secretary of the U. S. Navy. A. C. B.

ANNUAL REPORT OF THE SEC. AND TREAS. OF THE U. S. NAVAL INSTITUTE.

To the Officers and Members of the Institute.

Gentlemen:—I have the honor to submit the following report of the affairs of the Institute for the year ending December 31, 1889.

ITEMIZED CASH STATEMENT.

Receipts.

Items.	First Quarter.	Second Quarter.	Third Quarter.	Fourth Quarter.	Totals.
Advertisements	$50.00	$30.00	$110.00	...	$190.00
Dues	1153.00	574.78	168.00	$90.25	1986.03
Subscriptions	88.25	114.25	215.60	136.75	554.85
Sales	235.77	157.70	3.80	102.80	500.07
Life-membership fees	...	30.00	...	60.00	90.00
Interest on bonds	44.58	18.00	18.25	18.00	98.83
Binding, extra	19.60	3.00	3.00	1.00	26.60
Sundries	...	1.00	...	...	1.00
Totals	$1591.20	$928.73	$518.65	$408.80	$3447.38

Expenditures.

Items.	First Quarter.	Second Quarter.	Third Quarter.	Fourth Quarter.	Totals.
Postage, freight, etc.	$42.65	$25.83	$25.41	$39.30	$133.19
Stationery	80.36	29.24	1.50	12.13	123.23
Messenger	97.00	105.00	105.00	112.00	419.00
Branch expenses	1.77	...	...	...	1.77
Extra binding	...	10.85	...	...	10.85
Purchase of back numbers	...	...	...	...	...
Publication	735.47	220.58	600.00	687.24	2243.29
Office expenses	9.97	3.62	12.00	6.72	32.31
Subscript'n Army and Navy Register	5.00	...	...	...	5.00
Purchase of bonds	123.75	...	...	...	123.75
Rebate on dues	3.00	...	9.00	...	12.00
Totals	$1098.97	$395.12	$752.91	$857.39	$3104.39

SUMMARY.

Balance of cash unexpended for year 1888	$715.28
Total receipts for 1889	3447.38
Total available cash for 1889	$4162.66
Total expenditures for 1889	3104.39
Cash unexpended, January 1, 1890	$1058.27
Cash held to credit of Reserve Fund	198.87
True balance of cash on hand, January 1, 1890	$859.40
Bills receivable for sales of No. 51	75.00
" " " dues, 1889	633.30
" " " back dues	204.00
Total assets, January 1, 1890	$1771.70
Bill outstanding for No. 51	

RESERVE FUND.

List of bonds deposited for safekeeping in the Farmers' National Bank of Annapolis, Md.

United States 4 per cent registered bonds	$900.00
District of Columbia 3.65 per cent registered bonds	1000.00
District of Columbia 3.65 per cent coupon bonds	950.00
	$2850.00
Cash in bank uninvested	198.87
Total Reserve Fund	$3048.87
Annual interest on bonds	107.17
Number of new life members	3

During the year one District of Columbia bond, 3.65 per cent, was purchased for $123.75. Another has been ordered, and as soon as received the coupon bonds will be sent to the Treasurer of the United States, ex-officio Commissioner of the District of Columbia sinking fund, and registered in the name of the United States Naval Institute.

MEMBERSHIP.

The membership of the Institute to date, January 1, 1890, is as follows: Honorary members, 6; life members, 96; regular members, 573; associate members, 159; total number of members, 834.

The total number of members shows a slight decrease. This is owing to the fact that a number of names which have been carried on the books for some years without profit to the Institute have been dropped. All the members now on the books are in good standing,

and in the cases where dues are still owing it is because the members are on distant service. The actual circulation has increased, as may be seen from the following:

Members	834
Subscriptions	263
Exchanges	63
Average sales per quarter	151
Total circulation per quarter	1311

Publications on Hand.

The Institute had on hand at the end of the year the following copies of back numbers of its Proceedings:

Whole Nos.	Plain Copies.	Bound Copies.	Whole Nos.	Plain Copies.	Bound Copies.
No. 1	202	...	No. 27	294	27
2	205	...	28	5	...
3	63	...	29	226	27
4	153	...	30	257	2
5	126	...	31	30	54
6	9	...	32	6	173
7	15	...	33	16	164
8	41	...	34	55	7
9	47	...	35	106	66
10	5	...	36	253	25
11	220	...	37	171	21
12	61	...	38	249	2
13	4	...	39	146	2
14	7	...	40	25	111
15	2	...	41	247	16
16	224	...	42	132	13
17	4	...	43	286	3
18	95	...	44	272	10
19	115	...	45	210	18
20	131	...	46	217	18
21	235	...	47	198	18
22	278	...	48	187	18
23	180	...	49	216	18
24	202	...	50	204	17
25	1145	42	51	229	18
26	207	77			

2. Vol. X., Part 1, bound in half morocco.
1. " " 2, " " "
1. Vol. XIII, " 2, " " "
1. No. 34. " " "
5. " " " calf.
6. " " full sheep.

The archive set complete, Vol. I. to Vol. XIII. inclusive, bound in full turkey.

All business communications should be addressed to the Secretary and Treasurer U. S. Naval Institute, Naval Academy, Annapolis, Md., and all postoffice orders, checks or drafts should be drawn in favor of the Secretary and Treasurer.

Very respectfully,

RICHARD WAINWRIGHT, *Lieut., U. S. N.,*
Secretary and Treasurer.

ANNAPOLIS, MD., *January* 1, 1890.